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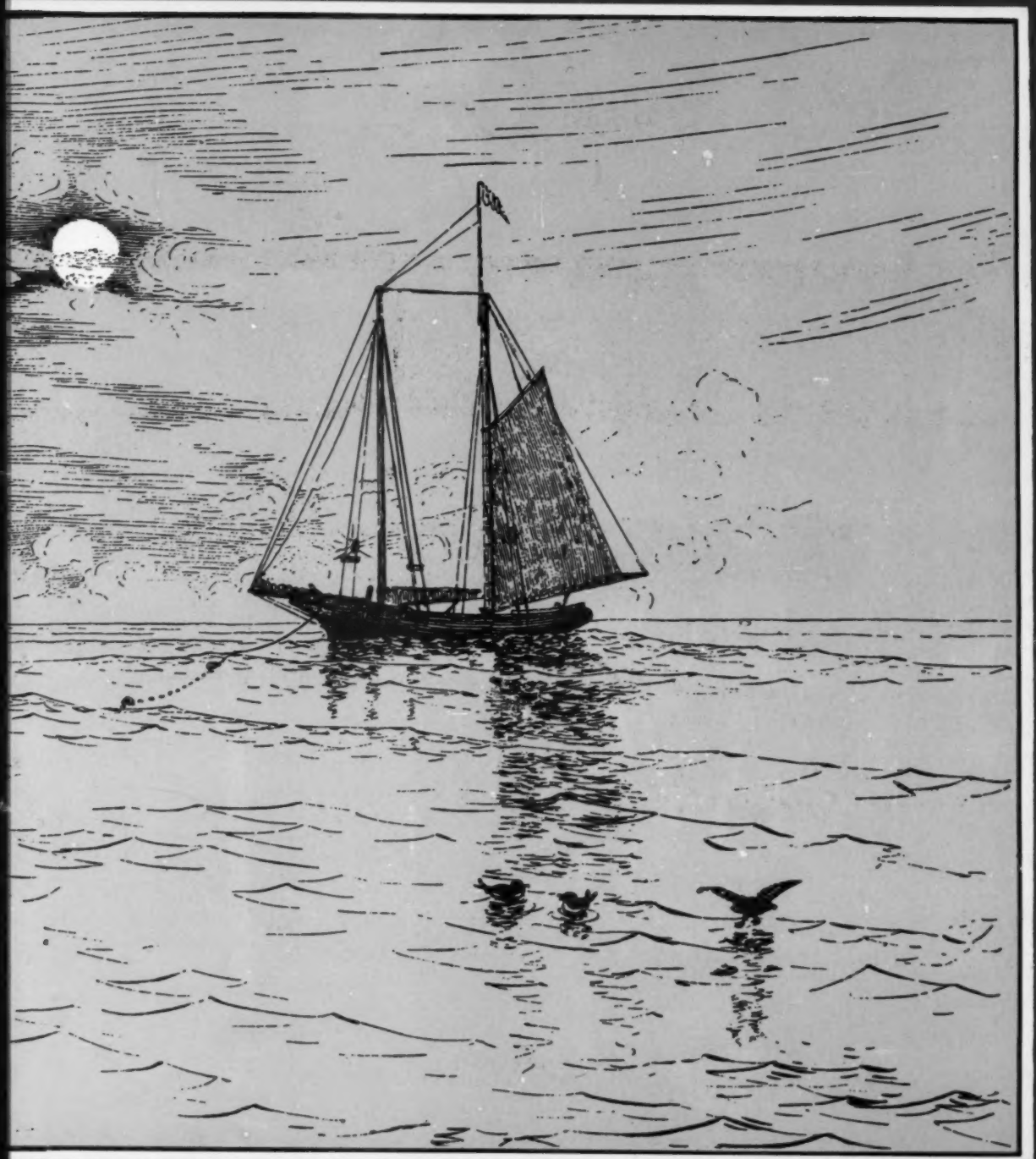

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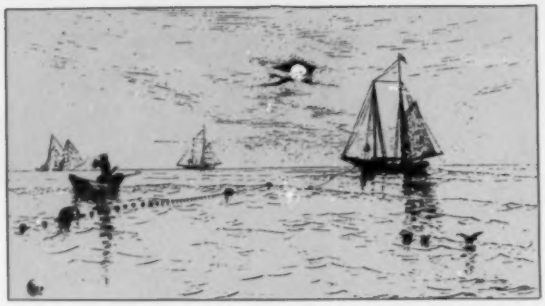
COVER

The mackerel gill-net fishery in 1887: drag-nets set at night off the Maine coast. (See article, p. 10).

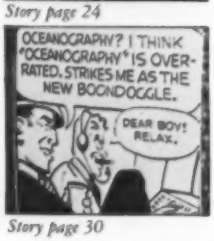


Story page 6

Story page 10

Story page 20

Story page 24



Story page 30

6 **Undersea Research Network Formed** — William S. Busch
Scientific exploration of coastal waters.

10 **Two Centuries of U.S. Fishing** — Joseph Pileggi
An American tradition.

15 **OTEC Pipes Up** — Richard Newell
Temperatures make the difference.

18 **Safer Commerce on the Seacoast** — Clay Rooks
Meteorologists doing their part.

20 **3,000 Meters Under the Sea** — Robert W. Embley
Birthplace of metals.

24 **Cityscape**
With or without chicory.

26 **Violent Continent** — Louise Purrett-Carroll
Atlantis off our shores.

30 **Changing Tools of a Changing Trade** — Carl Posey
Computers haven't replaced muscles.

34 **Seafare**
Hot and hearty for winter evenings.

Outlook For America's Fisheries

Terry L. Leitzell

Assistant Administrator for Fisheries

The American fishing industry, one of America's oldest, is now one of the most exciting, with a high potential for development and growth. With a combination of its traditional ingenuity, new investment, and innovative business practices, the industry can expand and utilize most or all of our ocean resources by the end of the decade.

The recent past has been a mixture of great progress and severe economic pressures for American commercial fishermen. From 1975 to 1979, the value of our catch jumped from $977 million to $2,234 million, a 70 percent increase in real terms. Moreover, although the United States continues to rely heavily on imports, the industry increased its exports by 255 percent. On the other hand, fuel price increases—up by more than one third in 1980—sharp reduction in demand for shrimp, and low prices in the New England groundfish and Alaska salmon fisheries have hit many fishermen hard, threatening their financial capability in some cases.

Through the National Marine Fisheries Service and the Sea Grant College Program, NOAA is moving in several ways to deal with industry problems and strengthen its ability to increase efficiency and productivity. Among the areas where NOAA is increasingly active are technology-oriented research to increase productivity and improve the industry's competitive position, expanded programs in seafood marketing with special attention to underutilized species, and stimulating export markets.

Substantial progress has already been made in our new "fish and chips" policy that links foreign fishing allocations in our 200-mile fishery conservation zone with improved access to foreign markets for our exports. Japan, for example, has recently implemented liberalized import rules that should substantially benefit the U.S. industry. Spain and the Federal Republic of Germany have also provided new market opportunities. Other countries are showing increased interest; most foreign nations are now convinced of our determination to obtain a quid pro quo for our agreement to permit them to fish in our conservation zone.

Congress has also been moving aggressively to encourage fisheries development with each house having passed different versions of major legislation. NOAA is working closely with Congress to achieve passage of effective legislation. A second major initiative is protecting our fishery resources from the destruction and pollution of the highly productive coastal habitats of our fish. From 60 to 80 percent of commercially valuable fish use estuaries, salt marshes, or mangrove swamps during some part of their life cycles. NOAA is taking a more active role in influencing decisions on use of the marine environment for such activities as petroleum exploration, waste disposal, and construction. The offices of Coastal Zone Management and Marine Pollution Assessment work closely with NMFS in preparing the NOAA positions.

We are also assessing our overall approach to the fishery management system established by the Fisheries Conservation and Management Act. Most of the major fisheries off our coast have now been brought under fishery management plans developed by the Regional Fishery Management councils. Decisions required to produce these plans, and to carry them out once adopted, are frequently very difficult. Is the system imposing an unduly onerous burden on the fishing industry? Do the benefits of management substantially outweigh the costs? Can we find less costly and more efficient management schemes? Are we dealing adequately with both recreational and commercial issues?

We want to be careful not to overmanage the fisheries. Multispecies and multiyear plans offer great flexibility in this complex arena, and perhaps will enable us to shift our focus to monitoring and improving the quality and efficiency of management.

NOAA's role in fisheries has changed dramatically during this Administration. Effective management, development, and protection of habitat are essential elements for growth and viability in the utilization of our living marine resources for food, recreation, and economic benefit.

Boost for marine science

UNDERSEA RESEARCH NETWORK FORMED

W.S. Busch

W.S. Busch is Senior Systems Engineer with the NOAA Undersea Research Program Office.

Scientists who want to work in ocean depths—to study the environment, the water, the life that exists there, the rocks and minerals of the seabead—have had to overcome some very special obstacles, and a great deal of imaginative engineering has gone into helping them get to work.

Scuba diving, which freed people from surface tethers and let them swim around relatively unhampered, was the first of these developments.

Underwater habitats have been built to sit on the ocean floor, while scientists swim out from them to undertake their research. Hydrolab, NOAA's chamber located off St. Croix, has been one of the most useful examples of this kind of solution, and it continues to serve as an underwater apartment—small, cramped, and humid though it may be—for visitors who spend up to a week under the water doing science.

Some habitats can be moved from place to place, such as the University of New Hampshire's Edalhab that was used in several locations over a two-month period some years ago in NOAA's Florida Aquanaut Research Expedition.

Submersibles—little submarines—have also proven to be very useful in getting scientists down to ocean depths. Most of them are relatively shallow water craft, best for studying the continental shelf and Gulf areas. The deep-diving *Alvin,* operated by Woods Hole Oceanographic Institution, and the lockout submersibles *Johnson Sea Link I* and *II* of Harbor Branch Foundation (a diver can be "locked out" at a selected depth, swim around for a while, then re-board the craft to return to the surface), are among the Nation's most useful submersibles with special capabilities for research.

And there are combinations and permutations and technological advances that lend themselves to many of the special undersea requirements of different kinds of research. Diving bells, both "wet" (where the interior is flooded, and the operators have to wear scuba gear) and "dry" (where water is kept out of the interior), personnel transfer modules, portable recompression chambers—a large assortment of general- and special-purpose facilities can be called upon in the service of science.

Early in 1981, for the first time, a nationwide network of such facilities is going to get under way, working through universities, and offering a wide variety of equipment and laboratory services, planned and selected by scientists to meet the research needs and environmental conditions in their individual regions. Known as NOAA's Regional Undersea Research Program, the network will consist of the already operational Hydrolab that Fairleigh Dickinson University operates for NOAA, the Southeastern Undersea Research Facility (SURF) operated by a consortium headed by the University of North Carolina at Wilmington, the Western Regional Undersea Laboratory (WRUL) operated by the University of Southern California, and the Hawaiian Undersea Research Laboratory (HURL) of the University of Hawaii.

The kinds of science that will be undertaken at these facilities will include learning more about fishery

Opposite page:
Santa Catalina Island kelp beds are a special kind of ecosystem where marine scientists will conduct their research.

Below:
Undersea research site of the University of Southern California is a well-sheltered cove with direct access to open water.

Dr. Andrew Pilmanis, University of Southern California

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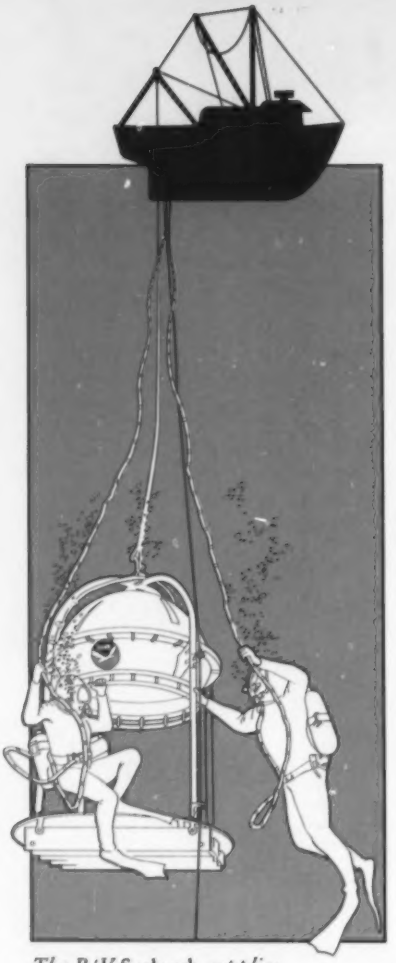
Lewis Trusty, Trusty Productions Inc.



The R/V Seahawk *supplies air, communications, and a tether from the surface for scientists working out of the wet bell on the sea floor.*

stocks and their management...investigating the effects of pollution and ocean dumping...devising ways to use the oceans' latent heat as an energy source...getting a better understanding of ocean currents and of their sometimes mysterious shifts...protecting marine mammals...answering questions of marine geology and composition of the continental shelf...solving whatever research problems seem important to undertake.

All proposed research projects will be carefully reviewed by scientific panels both for scientific merit and for feasibility of accomplishment in the facility selected.

The four locations will offer research opportunities in tropical island waters, a mid-Pacific archipelago, a temperate water kelp forest, and an Atlantic continental shelf environment.

The four facilities will be as diverse as the marine environments they serve. Dr. John Craven, Dean of Marine Programs at the University of Hawaii (and Marine Affairs Coordinator for the State) defined the problem: "The marine science community needs an ensemble of truly national undersea facilities available for use by researchers from all over the country, whose operational sites are driven by the scientific need."

The new network will go far to meeting the need Craven expressed. Hydrolab is a habitat located in a submarine river canyon in the Caribbean. The University of Hawaii will use the submersible *Makalii* (formerly *Star II*) with its associated Launch-Recovery-and-Transport (LRT) vehicle, and the habitat Aegir. The University of Southern California will develop a new habitat system sited in an offshore kelp forest. The University of North Carolina is designing a highly mobile surface-supported dive system.

Each of the universities will emphasize pesonnel safety and equipment reliability, and each will have a dedicated hyperbaric chamber to treat diving-related emergencies. Detailed periodic inspections and classification will be made by the American Bureau of Shipping, and formal reviews of their daily operations and safety plan will be conducted by the NOAA Diving Safety Board.

Each university is developing its own science program independently of the others, built around its unique capabilities and its research environment. Their interrelationships will stem from their involvement with NOAA's undersea research missions and goals, which, in turn, are based on those identified in studies of the Ocean Sciences Board of the National Academy of Sciences and NOAA's mission needs.

At Hawaii, the most important projects are those dealing with evaluation and development of natural resources (including energy) and those that help get a better handle on environmental processes and management of marine ecosystems. *Makalii* will begin operations early in 1981, to start on this work.

Makalii (the word is a Hawaiian term meaning "eye of the sea") is a two-person (pilot and scientist) vehicle capable of operating at depths down to 1200 ft. It allows the scientist to observe, take pictures, gather samples, and implant instruments on the seafloor. It has a life-support capability of 48 man-hours maximum, and can cruise underwater at 1 knot for up to 10 hours.

The LRT—designed for launching and retrieving *Makalii* in rough Hawaiian waters—is a towed wet submersible controlled by scuba divers. It submerges to about 50 to 100 feet with the submersible sitting on its deck, releases it in the calm sub-surface water, then resurfaces. When *Makalii* returns from its mission, the LRT is towed into position, resubmerges, and the submersible lands on deck, is secured, and then the LRT resurfaces with the submersible.

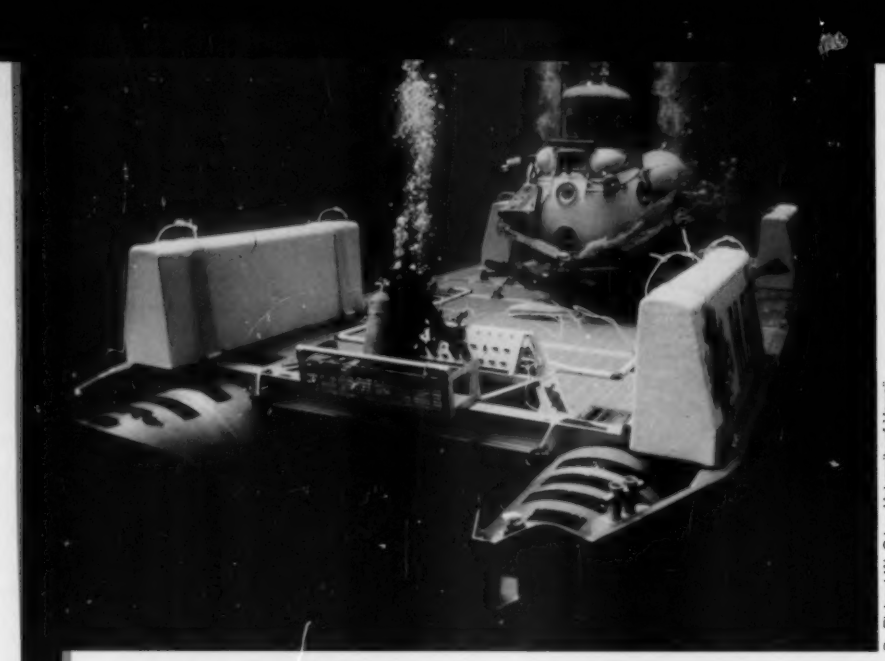
Craven is also working with NOAA to determine how best to use Hawaii's habitat, Aegir, for scientific activities. The habitat would be refurbished and modified for use to a maximum depth of 200 feet. It would allow 6 scientists to live on the ocean floor, working in the water and conducting laboratory experiments on site for up to two weeks.

According to USC's Science Director for its regional program, Dr. Robert Given, "The on-going undersea science activities at the Catalina Marine Science Center could keep a habitat facility busy for ten years, located in the kelp beds." The program will be integrated into the existing undersea science program at the Catalina Center.

The site is located 1200 feet offshore at a depth of 50 feet amid a lush bed of giant kelp, adjacent to an extensive rocky reef and a biologically productive soft bottom of shelly sand. Specific areas of research will include fisheries nearshore resource management, marine pollution, and seafloor properties and processes.

The proposed facility consists of a habitat capable of remaining at the experimental site for extended periods of time using direct shore support through an umbilical supplying power, water, communications, high and low pressure air, and data transmission capabilities. It will be possible to move the whole system from place to place, so that a variety of environments can be studied.

Alternatives will be looked at, such as a habitat designed for routine submerging and recovery with a



Dr. Richard W. Grigg, University of Hawaii

Left:
At 50 ft. below the sea surface, divers on the LRT launch the Makalii *to begin its mission.*
Above:
Hydrolab, located at the head of an underwater canyon off St. Croix, receives its air and electrical power from a surface support buoy.

submarine-type ballasting system. A launch and recovery system may be designed to use an existing marine railway, winch system, and waterfront hanger.

An important aspect of this habitat program is that it is in a temperate rather than tropical water environment.

The SURF program coordinated by the University of North Carolina is sponsored by a four-state consortium known as the Southeast Consortium for Undersea Research Efforts (SECURE). The consortium members are academic organizations, research institutions, and government agencies from Virginia, North Carolina, South Carolina, and Georgia. Their objective is to develop a unique research diving system designed to accommodate a wide range of research needs expanding from scuba, surface supplied dive systems, and open and closed bell diving systems, to lockout submersibles. SECURE's facility will be a highly mobile system capable of operations offshore anywhere along the U.S. Atlantic Coast.

The science program is developed around the basic areas of marine fisheries, seafloor processes, marine pollution, and ocean services. Its objectives are to collect and analyze information on important fishery stocks and habitats and on commercial fishing gear, to investigate optional sites for ocean dumping, to analyze sediment dynamics, and to collect and analyze baseline biological data on marine pollution.

The program will begin by acquiring basic diving equipment and training diver-scientists to be effective undersea researchers. Scuba will first be used, leading to surface supplied diving systems with diving activities limited to depths less than 130 feet. Consortium members have committed a variety of resources to the program, including a 76-foot trawler, the R/V *Seahawk*. It will be modified to accommodate a surface supplied diving system using a wet bell, a decompression chamber, and a multi-point mooring capability.

The wet bell, a moving platform guided by a cable from the support ship to the seafloor, will act as an elevator to ferry the divers from the sea surface to the ocean floor. It is also an emergency and safety refuge supplying the divers breathing gas from the surface within its bubble. Inside this bubble the divers can remove their masks, rest, and talk freely.

Eventually, as the program matures, experience grows, and greater depths are required, a more sophisticated system such as a deep diving closed bell system or a manned submersible is envisioned.

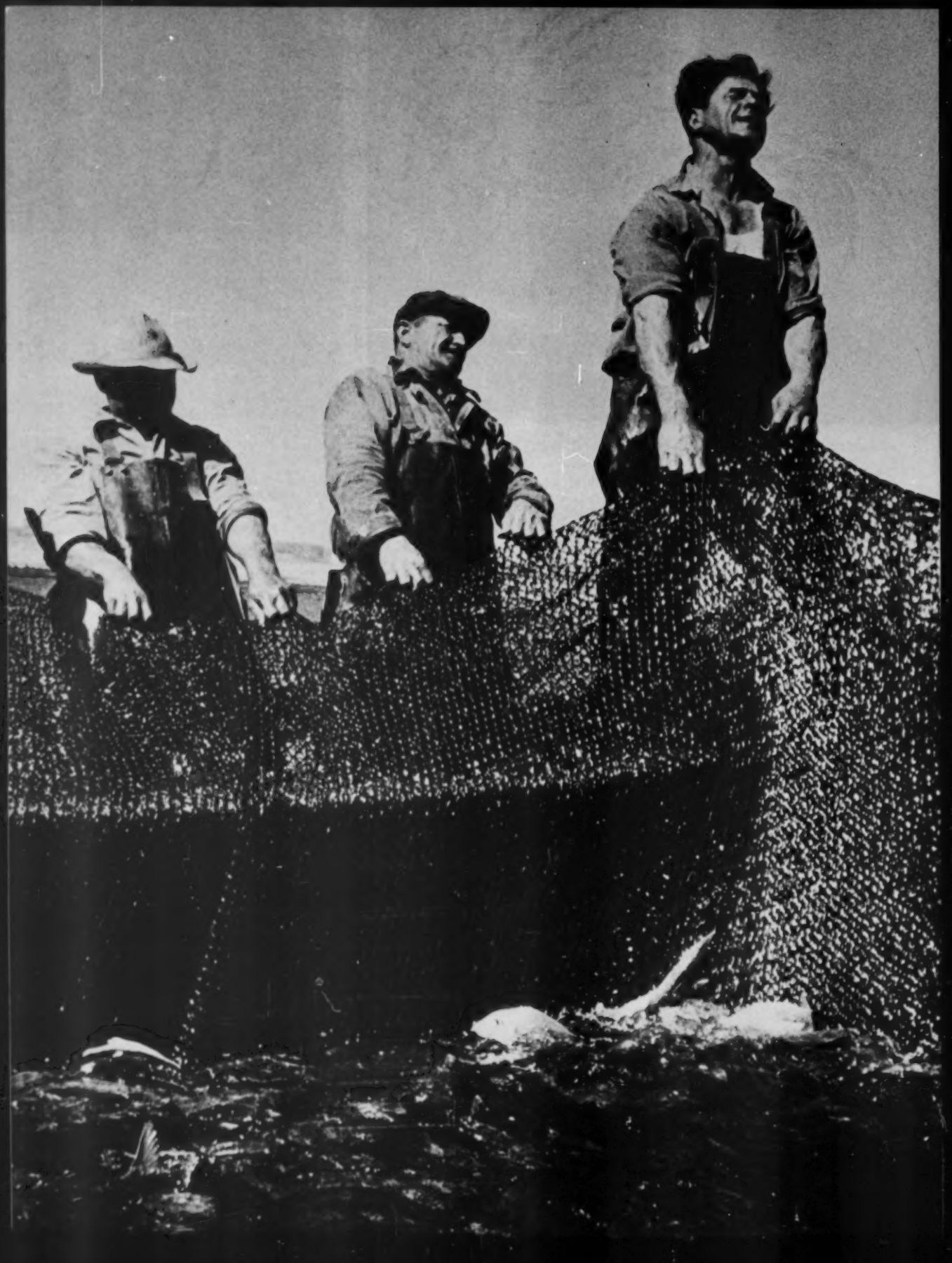
SECURE will also conduct undersea activities cooperatively with other groups experienced in undersea activities, using sophisticated systems such as diver lockout submersibles.

The primary facility of NOAA's ongoing program at St. Croix is the Hydrolab. Since its first scientific mission in May 1978, the program has averaged 14 missions a year with both American and foreign scientists participating. Missions have included studying the feeding patterns of fish and their reactions to light, effects of daily changes on distribution and abundance of fish, coral distribution, and effects of floating vegetation on the ecosystem. The primary objective is to acquire scientific information on coastal and tropical marine environments and to develop new and improved underwater research and engineering techniques, instrumentation, and equipment.

Hydrolab is a chamber containing laboratory facilities and living quarters, with viewports for external observation; it is equipped to support four divers for as long as 14 days. Life supporting air and power as well as communications are supplied via an umbilical connected to a life support buoy on the surface. A submerged back-up high pressure air hose and communications wire run directly from the habitat to the operations control base on shore.

A double lock decompression chamber is maintained on shore for treating injured divers if the need arises.

The NOAA Undersea Research Program will become operational in steps. Hydrolab is an ongoing facility; the University of Hawaii regional laboratory will start up early in the year. The southeast and California laboratories will follow along over the next two years, with continuing improvement and additional capabilities to be added. All together, the four laboratories are expected to offer American scientists a major boost in their efforts to understand the important problems of the sea by allowing them the opportunity of working directly in the sea.



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America's first industry

TWO CENTURIES OF U.S. FISHING

Joseph Pileggi
Joseph Pileggi is Chief, Resource Statistics Division, National Marine Fisheries Service

The United States has always been a fishing Nation. Fish and shellfish, abundant along the shores, were among the first of its natural resources discovered by settlers. Finfish, oysters, crabs, lobsters, and other aquatic products nourished the early colonists. Later, these commodities became articles of trade with settlements inland, up river, and in the mountain foothills. Little by little, the fisheries grew. During the nineteenth and the first half of the twentieth centuries, trade in fishery products made the United States one of the world's leading shipping and fishing nations.

Though made up primarily of small craft, today's U.S. fishing fleet covers vast distances in search of fish and shellfish. Commercial fishing is carried on off the entire U.S. shoreline, nearly 90,000 miles long with all its indentations; inland lakes, rivers, streams, and farm ponds, and on the high seas off Canada, Latin America, and in the last few years, off western Africa.

The tradition-steeped fisheries of the Atlantic Coast, the birthplace of U.S. fisheries, extend from northern Maine to the southern tip of Florida. North Atlantic Coast fishermen sail "down east" to take ocean perch in the Gulf of St. Lawrence and on the Grand Bank off Newfoundland. Flounders, cod, haddock, pollock, whiting, other bottomfishes, herring, northern lobster, and scallops are caught on the broad and the prolific Continental Shelf off new England. Farther south, there are widely spread fisheries for menhaden, clams, shrimp, crabs, and oysters.

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Rhode Island fishermen (opposite page) are shown trap fishing.

Nutrient-rich estuaries and inshore waters, like the Chesapeake Bay and Pamlico Sound, are found along many parts of the Atlantic Coast.

Most of the Gulf of Mexico was once considered an aquatic desert. These waters now yield great quantities of fish and shellfish. The most productive stretch of water fished by U.S. fishermen is in the Gulf of Mexico between Pascagoula, Miss., and Port Arthur, Tex. Fishermen from southern ports seek shrimp in the Gulf of Mexico, and as far south as the waters off eastern Central America and northeastern South America. Menhaden is fished off Alabama, Mississippi, Louisiana, and Florida. Other species harvested are red snapper, bottomfish, oysters, blue crab, and spiny lobster.

On the Pacific coast, the salmon fisheries long have been important to Alaska's economy. No greater misstatement could have been made than the one dubbing the purchase of Alaska "Seward's folly." Besides these salmon fisheries, stretching from the frigid waters of the Bering Sea south to the British Columbian border, fisheries for halibut and other bottomfishes, herring, shrimp, and Dungeness, king, and snow crabs contribute mightily to the State's welfare.

In the Pacific Northwest states of Washington and Oregon, salmon, albacore tuna, crabs, and oysters as well as bottomfish are the important species. Snug harbors in Puget Sound and elsewhere along the coast are ideal for vessel operations that range from northern California to Alaska.

The Pacific Southwest once produced the greatest volume of fish landed anywhere in America. This was largely due to the enormous catches of Pacific sardine, a fish that has all but disappeared. The major fisheries of the area are now tunas and anchovies. The tuna fisheries are found mainly along the Pacific Coast as far south as waters of Ecuador, Peru, and Chile. Some tuna also are fished in the South Central Pacific and Hawaii, and the central Pacific.

Interior waters of the United States—primarily the Great Lakes and the Mississippi River and its tributaries—yield harvests of fresh-water species. Though only a small part of the total U.S. catch, these species are important to the fishing industry.

Today there is a small but growing aquaculture industry in the United States. Complete data to measure the importance of "fish farming" are not available, but we do know that the cultivated catfish rose from 3.2 million pounds (live weight) in 1970 to an estimated 41 million pounds in 1979. Some estimates place current catfish

production at 84 million pounds. The main production of pond-raised catfish is concentrated in the river basins of the Gulf Coast and the southern half of the Mississippi River drainage system, especially Arkansas, Mississippi, and Louisiana. Some rainbow trout, shrimp, crayfish, clams, and oysters are also cultivated.

The Founding Fathers, hammering out the U.S. Constitution, left responsibility for the administration and management of fisheries in the hands of the States. All of the original "Thirteen" faced the sea or had direct communication with it.

Nevertheless, right from the beginning, the Congress showed its interest in fisheries. To help the new Nation's oldest industry, the First Congress granted fisheries, heavy users of salt, relief from the 6-cents-a-bushel salt tax. For every quintal (220 pounds) or barrel of pickled fish exported, a payment of 5 cents was authorized. The Second Congress repealed the 5-cent payments and substituted a direct subsidy to both vessel owners and fishermen.

In time, the number of fishermen and the size of their vessels increased, and fishermen roamed farther and farther from shore for their catches. Fishermen from different States soon found they were often competing on the same grounds for the same fish not only with each other but also with foreign-flag vessels. Some central authority was needed to adjudicate the inevitable conflicts in so competitive an activity, where proof of ownership resides soley in possession. After it had become apparent that some valuable species were being overfished, the Federal Government was designated to examine, give financial support in the latter part of the eighteenth century and to rectify the situation.

The U.S. Government's formal interest in commercial fisheries began after the Civil War when New England shore fishermen had a series of poor catches. To find out why, the United States Commission, Fish and Fisheries (the "Fish Commission") was established in 1871. Spencer F. Baird, Secretary of the Smithsonian Institution and a naturalist of international repute, was named the first Commissioner of Fish and Fisheries. The Commission was given the additional mandate of artificial propagation of fish in its second year.

These were some of the highlights of the Commission's report in 1880 after a decade of service:

- German carp and shad produced in large numbers and distributed to various parts of the country
- a special steamer, the *Fish Hawk*, built to explore the Gulf Stream and its fauna and, especially, to determine the distribution of tilefish (a species rarely fished today)
- the fisheries explored on the U.S. Atlantic Coast, the Great Lakes, the Gulf of California, and the entire West Coast from San Diego to Point Barrow in the Arctic Ocean.

According to one tidbit from that report, there was a food fish propagation station at the Navy yard in Washington, D.C., for hatching shad eggs obtained from the Potomac River. A total of 29,296,000 eggs were hatched and planted from this station and another at Havre de Grade, Md.

Those were adventurous days for some fishery workers. The 1880 report stated that the War Department had sent a detail of soldiers to protect the McCloud River Salmon hatchery in California against Indians and lawless whites. For other military men, on the other hand, life may have been less eventful—perhaps for the Army Signal Service personnel assigned to observe water temperatures and their relation to the movement of fish.

After Baird's death in 1887, his multidisciplinary approach to fisheries management was largely discarded, and propagation was stressed above all else. In time, this new emphasis proved an oversimplified solution to the complex problem of maintaining high fishery yields.

The Fish Commission and the Office of Commissioner of Fish and Fisheries continued as an independent agency of the Federal Government until July 1, 1903, when it was placed in the newly created Department of Commerce and Labor (see Chronology). Since becoming a part of the National Oceanic and Atmospheric Administration in 1970, the fisheries previously commercial orientation has broadened. The National Marine Fisheries Service looks after resources that interest both commercial and recreational fishermen, who often prize the same species of fish or shellfish.

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Tuna fishing before purse seines ...single pole fishing off Southern California for yellowfin in the 50's.

Fishing trawlers tied up at Boston's Fish Pier, 1949 (opposite page), as fish carts take on their cargoes, bound for the processors.

NMFS is also responsible for marine mammals and endangered marine aquatic species.

The two centuries since the birth of the Nations have seen the evolution of fishing vessels and techniques.

The first U.S. fishing fleets consisted of small, oar-propelled boats and sailing vessels. By the late 1800s, steam-propelled vessels journeyed 2,000 miles from Gloucester, Mass., to Davis' Strait off Greenland. There, using lines with many baited hooks kept afloat, sometimes for miles, by buoys, the fishermen "trawled" for halibut, bringing back their cargoes to Gloucester in "flitches," fillets. In 1880, one steam vessel, the *Caleb Eaton*, brought back 177,300 pounds of salted halibut in a single trip. The average for a trip was 113,233 pounds. Most fishing was done in July and August.

One Fish Commission staff member recounted his experiences while an observer collecting data on a fishing vessel out of Gloucester. He wrote: "I

National Archives

would like to put down some of the conversation of the crew, but there is too much profanity and vileness mixed with it to allow of its appearing on paper." As an example, the author mentioned the expression "A d--n nice thing."

By 1918, there were vessels with diesel-electric drive engines. The early powered vessels could attain speeds of 8-9 knots, compared with today's speeds of 12 knots or more. The motorization of vessels enabled an increase in trawling or dragging speeds, which resulted in bigger catches.

By 1930, there were only 30 steamers still in operation, compared with a hundred or more diesel-powered vessels; by 1940, only a handful of steamers. After 1930, there was also a change from wooden to steel vessels. Today there are boats of wood as well as glass-reinforced plastic, aluminum, and ferro-cement.

With the advent of the internal combustion engine, boats became only slightly larger. Even today, despite an increase in the number of large vessels being built, more than 9 U.S. fishing vessels in 10 are less than 70 feet long. Nearly 2 out of 10 fishing boats are of pre-World War II vintage.

U.S. stern trawlers, which fish the net from the stern instead of the side, were not built until the mid-1960s, many years after the United Kingdom, Japan, Germany, and others had put them to good use.

The U.S. industry has tried to use "factory" ships similar to the foreign vessels that both catch and process fish off U.S. coasts, but most such efforts have failed. U.S. labor costs of processing at sea are too high, even when fishermen can be found who are willing to spend a month or more at a time at sea.

The power handling of gear was another step toward the mechanization of fishing. Fishermen, whether on boats or ashore, use about 30 different kinds of gear. Out of this assortment, otter trawls and purse seines are by far the most important.

The success of the first mechanically propelled otter trawler fishing on the New England banks in 1905 started a rapid transition to current trawling methods of fishing. From over the side, the ship dragged a conical net along the sea bottom, its mouth held open by otter or trawl boards. Later, the otter trawl, replacing the haul seine, was the major gear used in expanding the Gulf of Mexico shrimp fishery.

The purse seine came into general use early in the nineteenth century. It is a large net set by two boats launched from the fishing vessel around a school of fish and closed or "pursed" at the bottom by tightening a line passing through brass rings at the lower edges. Next came power blocks to haul the seines, and airplanes to spot schools of fish. Hydraulic power was increasingly used to drive trawl winches and other dock machinery. Mechanization improved efficiency and led to reductions in crew sizes.

The improvement and development of electronic equipment during World War II resulted in extensive use by the fishing industry of such instruments as ship-to-shore telephones, loran (position plotter), radar, and automatic steering devices. Besides improving navigational safety and fishing productivity, this equipment has been responsible for the discovery of new fishing grounds and for making the operation of midwater trawls practical.

With the passage of the Fish and Wildlife Act of 1956 U.S. fisheries

The halibut fishery a century earlier , as a halibut schooner lies to in a gale on the Grand Banks near Newfoundland.

NOAA

The U.S. Fish Commission (below) in 1898 had headquarters in Washington, D.C., and its own railroad car, a rolling laboratory.

management finally came of age. The Act declared a national fisheries policy, reorganized the Fish and Wildlife Service, and assigned new tasks to the Federal Government. The Act recognized fish, shellfish, and wildlife as living, renewable resources capable of making a valuable and continuous contribution to the Nation's economy and food supply, and to its citizens' health, recreation, and well-being. If properly developed, managed, and utilized, these resources can be enhanced. The Act also recognized that fisheries directly and indirectly offer employment to substantial numbers of people and strengthen the defense of the country by training seafaring citizenry and maintaining fleets of seaworthy vessels. The Act also made available financial assistance for the fishing industry in the form of loans for financing and refinancing operations, maintenance, replacement, repair, and equipment of fishing gear and vessels.

In the 1960s, international competition intensified for the fish and shellfish once considered the preserve of U.S. fishermen. During the last two decades, foreign fishing off the coasts of the United States has expanded rapidly. Large, integrated foreign fishing fleets—consisting of fishing craft, factory ships, and support vessels—now operate on such prolific fishing grounds as Georges Bank (off Cape Cod) and in the eastern Bering Sea and the Gulf of Alaska. Foreign fishing activities, however, are by no means confined to these areas and have been reported off many others parts of the U.S. coasts, including the middle and south Atlantic, and Gulf of Mexico coasts.

The most important legislation of interest to fishermen in the last decade was the Fishery Conservation and Management Act of 1976. This established a fisheries conservation zone (FCZ) in which the Federal Government has exclusive authority over domestic and foreign fisheries within 200 nautical miles of U.S. shores and over certain living marine resources beyond the FCZ. With the FCZ, foreign vessels are permitted to fish only that portion of the "optimum yield" not harvested by U.S. vessels.

So much for the past two centuries. What of the future? The advent of the 200-mile legislation has given new impetus to U.S. fisheries. It remains to be seen what the industry does with this opportunity, whether it seizes this chance to develop fully the economic potential lying just off the coasts.

Fishing restrictions to protect different species will call for imagination in filling demand for fishery products at home and abroad. Hitherto untapped resources, perhaps, will be exploited and found to be tasty substitutes for the better known species.

With the cost of fuel rising almost monthly, high interest rates, and tight money, new fuel-efficient methods of fishing will need to be explored. To make fishing profitable, while keeping fish prices competitive with other protein foods, more economical ways will have to be found to harvest products from the seas and lakes and to accelerate the development of fishery resources off the U.S. coasts.

Clearly, if history is a harbinger of the future, we have only begun to realize the promise of the waters. As the world's populations and their expectations grow, the sea prefers new sources of nutritious food, minerals, and energy. It is ours for the taking, with careful management and conservation.

Chronology

1871 The U.S. Fish and Fisheries Commission is created to investigate the condition of U.S. sea coast and lake fisheries.

1872 The Commission is given the mandate for artificial propagation of fisheries.

1903 The Commission, renamed the Bureau of Fisheries, becomes part of the new Department of Commerce and Labor and receives jurisdiction over Alaska's fur seals, salmon, and other fisheries.

1939 The Bureau of Fisheries is transferred to the Department of the Interior.

1940 The Bureau of Fisheries becomes the Fish and Wildlife Service with the transfer to it of the Bureau of Biological Survey, and its functions.

1956 The agency becomes the U.S. Fish and Wildlife Service, consisting of two separate agencies: the Bureau of Commercial Fisheries and the Bureau of Sport Fisheries and Wildlife.

1970 The Department of Commerce receives jurisdiction over the Bureau of Commercial Fisheries, renamed the National Marine Fisheries Service, as part of the National Oceanic and Atmospheric Administration. NMFS also runs the marine game fish programs formerly administered by the Bureau of Sport Fisheries and Wildlife.

Library of Congress

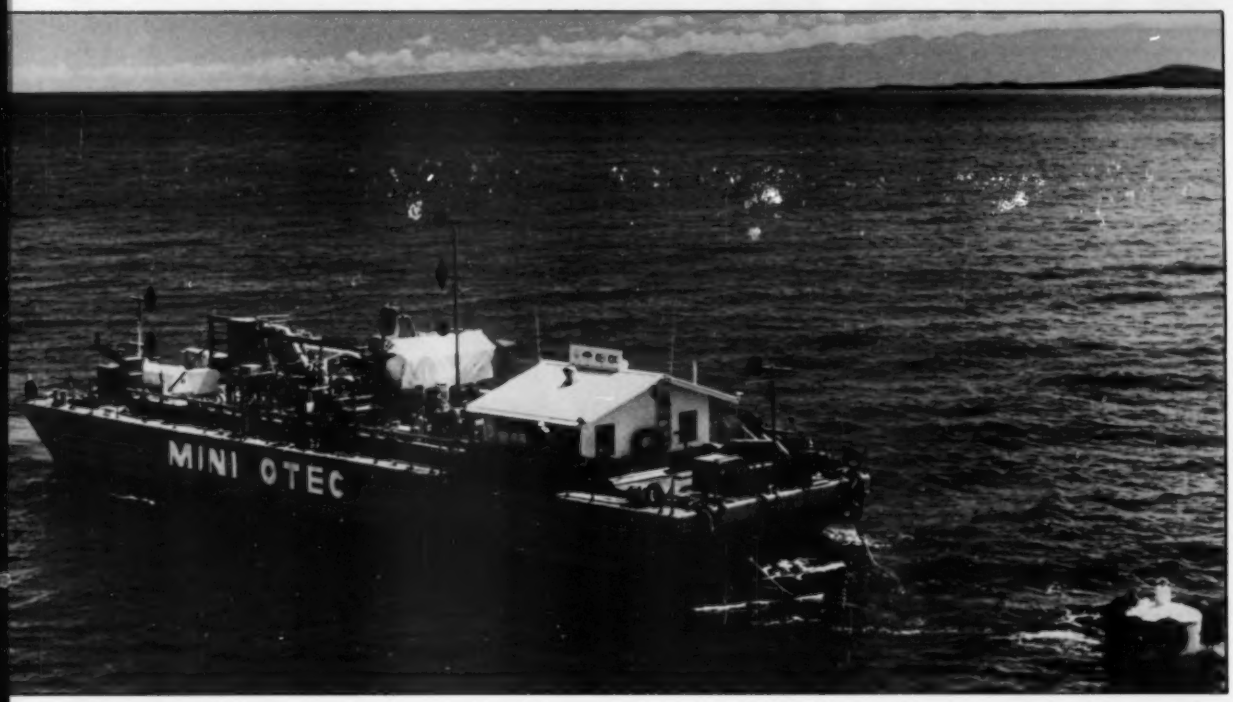
OTEC PIPES UP

Richard Newell

It could be Hawaii, Puerto Rico, or one of many other tropical or subtropical sites. Anchored just a few miles offshore, a large floating platform silently rides the warm ocean waters, carrying an array of pumps, evaporators, and condensers, all primed for action. From the bottom of the platform, a massive pipe, measuring 100 feet in diameter, drops down 3000 feet—more than halfway to the ocean floor—into a realm of perpetual cold and darkness.

All is ready. A signal is given, giant seawater pumps are switched on. Cold water surges up the huge pipe at a rate of 450,000 gallons per second, while warm water from the surface rushes into the system at the same rate—a total water flow equal to that of the Nile River on an average day.

This event, scheduled for the late 1980's, would mark the beginning of



Lockheed Missiles and Space Co.

Last year Mini-OTEC, developed by private industry and the State of Hawaii, generated 10 kilowatts, net, of usable power from ocean water temperature differences.

Ocean Thermal Energy Conversion (OTEC) on a commercial scale. By continuously circulating cold ocean water up from the depths, OTEC plants such as this could tap the solar energy stored in the warm surface waters of the world, each to the tune of 100 to 400 megawatts of electricity. About 70 percent of this power, the amount not used to pump the seawater, would be

cabled to shore for use by an electric utility company, at a competitive price.

The oceans offer several possibilities as sources of renewable energy—from the action of waves, of tides, of currents, from differences of salinity—but OTEC offers the most promise within the scope of today's technology. And the United States is setting the pace.

The OTEC alternative got a boost in the summer of 1979, three kilometers off Hawaii's Kona Coast. There, a 50-kilowatt, barge-mounted Mini-OTEC, developed without Federal help by a group of private companies and the state of Hawaii, generated usable power (10 kilowatts, net) for the first time from temperature differences in ocean water.

OTEC's true test, however, will come only when a full scale version is built, deployed at sea, maintained in good order, and operated without failure for several years. OTEC engineers are confident that the technical challenges can be met.

NOAA is assisting the Department of Energy in the ocean engineering and environmental aspects of OTEC. NOAA's OTEC program manager, Joseph R. Vadus, of the Office of Ocean Technology and Engineering Services, oversees the ocean engineering program, which includes the OTEC platform, mooring, cold water pipe, and seawater systems. In charge of some of the biggest engineering problems associated with these systems are Drs. Terence McGuinness and Richard S. Scotti, the latter on assignment to NOAA from the University of Southern California.

Full scale OTEC cold water pipes will be immense, dwarfing structures that today seem large. "If the 50-story-high Washington Monument could be crated up," says McGuinness, "six such crates stacked end to end would be about the size of a cold water pipe for a commercial OTEC plant." OTEC pipes will be the world's largest marine structures.

McGuinness explains that the uniqueness of the pipe lies not so much in its great mass as in its need to be flexible, to interact dynamically with the hostile ocean environment. It must survive that environment for the 30-year lifetime of the OTEC power plant. Accordingly, it is being designed to stand up to a tropical "storm of the century," such as last summer's Hurricane Allen, with wind speeds of 150 miles per hour and waves 40 feet high.

"Based on what we've learned in the past four years from theoretical models, laboratory experiments, and at-sea testing, we're confident that we could now build a successful 40-megawatt-size pipe," Scotti asserts. Nevertheless, they are proceeding systematically with further test programs to verify analytical models of the OTEC cold water pipe. Laboratory tests are being run with models ranging from a 1/30th scale 40-megawatt pilot plant, for turbulent internal flow tests, to 1/50th scale for tow and deploy tests, to 1/100th scale for hurricane-simulation tests. At-sea testing, planned for 1981,

Joseph R. Vadus, NOAA's OTEC Program Manager, visited the prototype Mini-OTEC plant off Hawaii.

will use a 1/3 scale model complete with platform, 10-foot-diameter by 1000-foot-long cold water pipe, and mooring system. Engineers will evaluate the performance of all the analytical models thoroughly before tackling the big one.

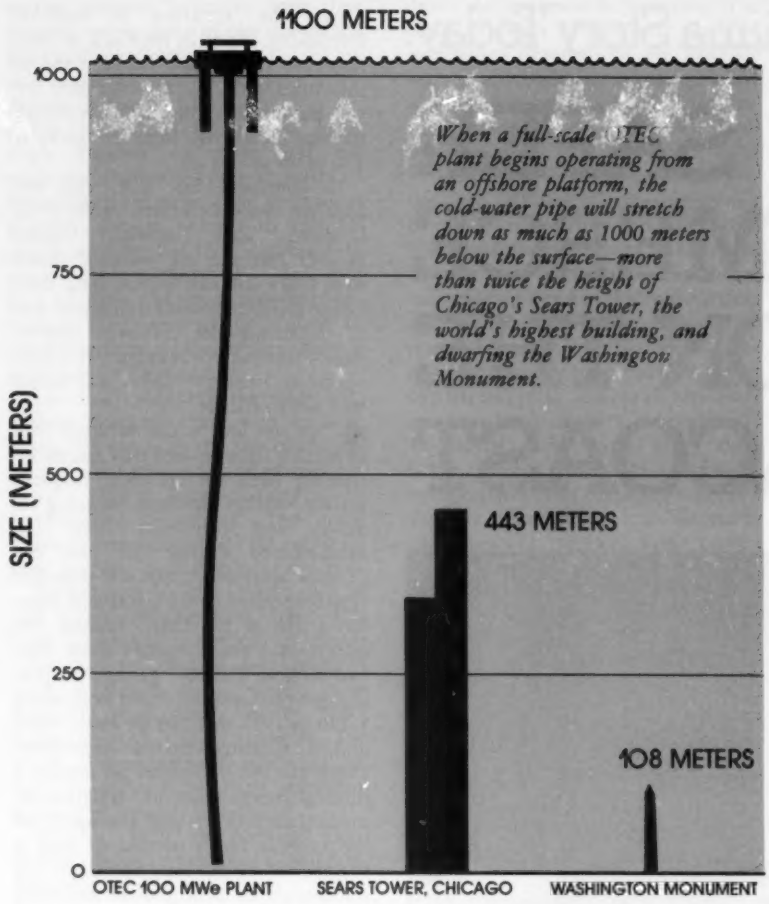
The goal of this Federal effort is to minimize the engineering risks, reduce the costs, and provide incentives for industry to proceed rapidly with construction of commercial OTEC plants. OTEC power is one of the few solar energy options that can provide electricity day and night, any time of the year. It has the potential to fill a significant portion of the world's energy needs, particularly for nations in tropical and subtropical regions.

OTEC can do more than supply electrical power from moored platforms. Self-propelled OTEC plantships, capable of seeking out the greatest temperature differences, could be used for on-board manufacturing of chemicals from the sea, such as ammonia, and metals such as aluminum, for worldwide markets.

The working principles that may bring all this about, in a time of dwindling oil and natural gas resources, are not complicated. In fact, the experts tell us that fuel-free OTEC power cycles are simpler than those of conventional power plants, which first require conversion of fuel into heat. In the "closed cycle" system used in Mini OTEC and slated for the OTECs of the '80's, warm sea-surface waters vaporize a working fluid capable of boiling and condensing over a small temperature range. Ammonia, which OTEC plantships can produce from the sea, happens to be the most favored working fluid. The expanding vapor drives a giant turbine generator, and then cold, nearly freezing, water circulated from great depths turns the vapor back into liquid for recycling.

A thermoelectric OTEC may be a promising variation of the closed-cycle system. Now in the early stages of laboratory experimentation at the Department of Energy's Solar Energy Research Institute (SERI), this system uses charged particles moving through solid state semiconductors in place of a working fluid. It requires no evaporator, condenser, or turbogenerator—just a power module consisting of compact heat exchangers integrated with thermoelectric generators. SERI workers claim that this solid state approach, if it proves to be viable, would be more reliable than the standard closed-cycle system and, by doing away with the need for handling ammonia, would be much safer as well.

The other type of OTEC system, the "open-cycle" type, uses warm seawater itself as the working fluid. The seawater is pumped into a vacuum chamber


1100 METERS
1000
750
500
250
0
SIZE (METERS)
When a full-scale OTEC plant begins operating from an offshore platform, the cold-water pipe will stretch down as much as 1000 meters below the surface—more than twice the height of Chicago's Sears Tower, the world's highest building, and dwarfing the Washington Monument.
443 METERS
108 METERS
OTEC 100 MWe PLANT
SEARS TOWER, CHICAGO
WASHINGTON MONUMENT

where a small fraction of it flashes into steam, drives the turbine generator, and is then condensed, by cold seawater, in order to maintain the pressure differential needed to drive the turbine. The condensed water can then be used for human consumption. Both the closed and open-cycle systems hold promise for commercial applications, although standard closed-cycle technology is more advanced.

Standard closed-cycle technology may experience another boost soon, when the Department of Energy's OTEC-1, a refitted Navy tanker, cruises to its site off the Kona Coast of Hawaii to test various OTEC components, particularly the heat exchangers—the evaporators and condensers that transfer heat between the water and the ammonia. Heat exchangers are a key cost factor in closed-cycle systems, because large amounts of water must be pumped past them in order to produce significant amounts of electricity. The large flow-by is required because of the small ocean temperature differences available, about 22 degrees Celsius (40 degrees Fahrenheit) in the tropics.

Because the heat exchangers are metal, they are especially susceptible to two seaborne problems—corrosion from the salty environment, and fouling from the tiny forms of marine life that attach themselves like barnacles to the surfaces. Either of these processes, if allowed to proceed unchecked, would drastically reduce the efficiency of the exchangers and the yield of electrical power, so OTEC-1 studies will concentrate on ridding the system of them.

Since power yield is so closely tied to the temperature differences between surface and deep-sea waters, it is important to select sites where the difference is large. Dr. George A. Maul of the Atlantic Oceanographic and Meteorological Laboratories is combining satellite information with ship and buoy data to find such sites. Any one technique, he explains, cannot satisfy all the OTEC user's needs. "Obervations from the surface provide limited coverage," he says, "and satellite sensors are subject to several compromises which include the spacecraft's orbit, atmospheric interference, and data calibration requirements."

AOML's Dr. Robert L. Molinari, who preceded Maul in the OTEC site evaluation program, used satellite data with on-site data to evaluate two deep-water Gulf of Mexico sites. He found that a site 150 kilometers south of Mobile, Alabama, is somewhat less favorable for OTEC use, because of colder near-surface waters, than a site 300 kilometers west of Tampa, Florida.

The broad scope of NOAA's involvement in OTEC is underscored by its concern for environmental impacts. Deputy Administrator James P. Walsh has stated, in testimony before Congress, that "Several aspects of OTEC operations might raise environmental concerns." These include the effects of an OTEC plant's thermal-plume discharge. The resulting changes in upper ocean chemistry and biology, and even in ocean circulation and the climate, are being carefully studied. "Environmental problems may also result from the use of toxic working fluids and of biocides to clean marine biological growth from the surface of heat exchangers and pipes," Walsh explains. Extensive studies of many of these problems have been supported by the Department of Energy for several years, and Walsh points out that these and other environmental questions will receive further attention before commercial operations begin.

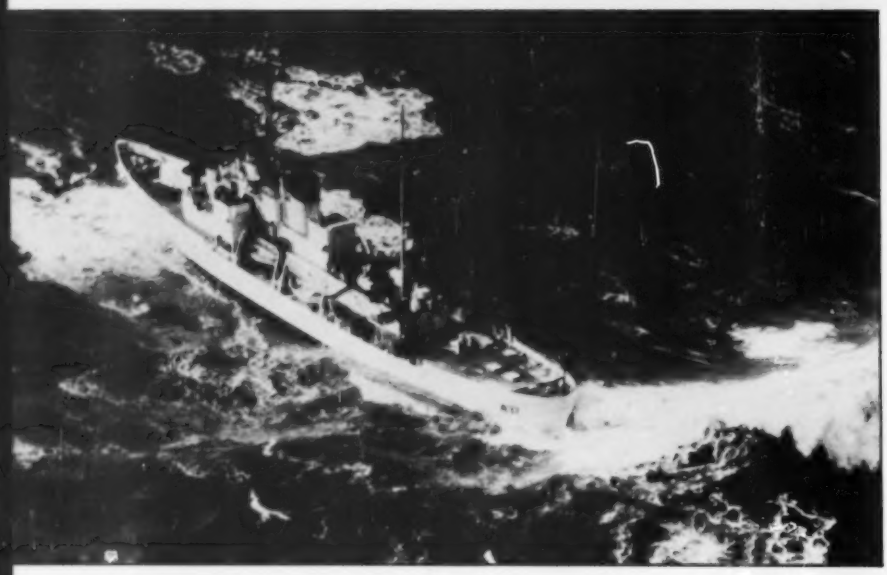
In August, President Carter signed a bill that established NOAA as the agency responsible for licensing and regulating commercial OTEC facilities, and for monitoring OTEC operations. This action occurred on the heels of legislation that accelerated the OTEC research and development program administered by the Department of Energy.

As OTEC pipes go up in the '80's, NOAA's role will be an expanding one, in terms of both technical development and environmental protection—helping to introduce a new source of renewable, low-cost energy to the Nation and the World.

Louisiana Story Today:

SAFER COMMERCE ON THE SEACOAST

Clay Rooks



More than half of all Americans live near our Nation's coastline, and by the end of the 1980s it is estimated that 75 percent of us will live and work in the coastal zone. As more and more people live near the coast, more and more of them will be found working and playing in or on the nearby seas.

Consequently, accurate weather forecasts are increasingly necessary, because marine activities—whether recreational outings or huge construction projects—are especially vulnerable to changes in the weather.

Clay Rooks is the Sea Grant science writer at the Center for Wetland Resources, Louisiana State University.

Accurate weather forecasting depends upon access to reliable, pertinent data. This has been hard to get in nearshore waters, because you just can't drop a weather station in the ocean like you can on land.

But the situation is improving. New technology, such as weather satellites, is making it possible for meteorologists to follow coastal weather systems more closely. Scientists, engineers, and forecasters are working together to improve the accuracy of weather forecasting. And, in the Gulf of Mexico, close cooperation between the oil industry and the National Weather Service has provided 58 weather reporting stations on oil rigs from the shore to 150 miles out to sea.

In Louisiana, Dr. S.A. Hsu and Research Associate Robert Sylvia of the Louisiana State University Coastal Studies Institute are working closely with NWS and the NOAA Data Buoy Office (NDBO) toward a common goal of improving the real-time weather data—nowcasts—beamed to boat operators, helicopter pilots, and others who work offshore.

Their test area is the northern Gulf of Mexico. It is an area that has an increasing need for accurate, frequent marine weather forecasts. Seagoing industry and commerce there has mushroomed during the past two decades. More than 2,800 self-propelled vessels operated by the gas and oil fleets are active in the Gulf. Fishing and recreational boats number more than two million. Offshore gas and oil production platforms increased from about 1,100 in 1964 to 3,700 by June, 1980, and in Louisiana's coastal waters alone about 150,000 passengers per month—drilling superintendents, roughnecks, medical technicians and managers, all the support forces needed to keep a vigorous industry strong—are transported by helicopter to and from facilities offshore.

The value of equipment and supplies transported in support of energy-related activities is estimated at several billion dollars annually. The cities along the Gulf coast have become major world shipping centers and their daily commerce is highly weather sensitive.

Alert to the needs of improved weather forecasting to support this burgeoning industry, the NWS office in Slidell, Louisiana, has greatly expanded its forecasts and nowcasts for the Gulf. Research to improve the service is also under way—and that is where Hsu and Sylvia enter the picture.

"To understand and forecast coastal weather a meteorologist must have a knowledge of oceanography as well as of atmospheric processes," Sylvia explained. Hsu elaborated: the coastal zone is the interface of the land, sea, and air masses—all of which interact dramatically on conditions forming weather and affecting its changes. The

marine weather forecaster must thus consider topography of the coastal sea floor and the shoreline as well as the action of the sea itself, in response to atmospheric forces.

The land-based Continental Polar High Pressure air mass and the maritime Bermuda High Pressure air mass (which are more or less permanent features, though subject to seasonal shifts) account for U.S. southeastern area weather at large. The dry, cold land air mass and the moist, warm sea air mass create weather fronts along an atmospheric battle line as they struggle endlessly for dominance.

The sharp difference between land and sea along the coast, with resultant sharp differences in the rate of absorption of solar radiation and of cooling, cause sharp local changes in temperature, humidity, and wind characteristics. Coastlines are noted for their highly changeable local weather.

To improve weather predictions in this highly unstable zone, more data from the sea side is needed. Until only a few years ago, surface observations in Gulf of Mexico coastal waters came primarily from ocean vessels, NWS coastal stations, and oil platforms. The pieces of meteorological data obtained were inadequate for high resolution support of weather forecasting.

In June 1979, the National Earth Satellite Service established a Gulf Support Unit at NWS's Slidell station. Mission: to strengthen satellite services used for weather forecasting over the Gulf. Information obtained from satellites includes land-to-sea temperature gradients (differences), cloud top and sea surface temperatures, cloud and rainfall patterns, and rates of movement. All together, they make a three-dimensional atmospheric picture that meteorologists use to forecast frontal movement and action.

Additional surface measurements, as well as satellite data, are also needed. Many of them come from the network of unmanned data buoys developed by NDBO (3 of which are located along the 26th parallel in the Gulf), but they are too far offshore to record nearshore dynamic conditions. They will therefore be supplemented by an intermediate line of shallow water stations.

The first opportunity for such a station arose when NDBO recently deployed a NOMAD buoy for research purposes near the 29th parallel. In addition to its research function, it is equipped with sensors that transmit continuous observations on localized sea and air conditions to scientists and weather forecasters via NOAA's network of satellite and land line communications.

There is also GOWON. GOWON—the Gulf Offshore Weather Observing Network—is a joint venture between NWS and the petroleum industry. In October 1979, the industry began volunteering weather observations from many of its oil and gas production platforms and drilling rigs in the Gulf. The observations vary from rudimentary to sophisticated. Several include oceanographic data. Some are automated and report every three hours, while others are twice-a-day voice reports. The companies transmit the data to land, where it is collected by the weather service and private meteorologists for weather forecasts.

The raw data must be reformatted before it can be entered into the National Climate Center data banks. NWS has asked Hsu and Sylvia to use the LSU Coastal Studies Institute as the collection point for data from Houston, Texas, and from Slidell, Lake Charles, and Lafayette, Louisiana. They reformat the data to NWS standards, and use it both for their coastal weather models and for relaying on to the National Climatic Center.

To fine-tune the coastal weather forecasts that are so vital to commerce and industry in the offshore zone, Hsu and Sylvia have devised five primary models:

A coastal front movement model, to monitor weather fronts and make possible forecasting wave and sea states;

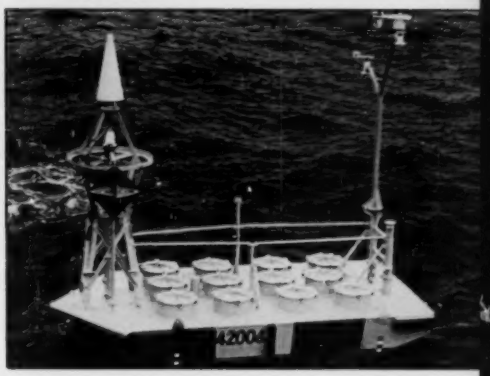
A coastal jet stream model, to measure extreme wind conditions that are important to helicopter pilots flying over the Gulf;

An offshore wind prediction model, to integrate temperature gradients and make possible predictions of offshore inversion layers, which often cause air pollution;

An ocean thermal front monitoring program, for further studies of sea surface temperature gradients where many species of fish, such as tuna and menhaden, often congregate—valuable information for commercial fishermen;

A fog prediction and dispersion model based on coastal sea surface temperatures, to determine visibility affecting ship movements along the coast.

Ship at sea in a storm (facing page)—heavily dependent upon timely, accurate weather forecasts. NOAA Nomad buoy (below) is providing Louisiana State University meteorologists real-time data for their modeling studies.

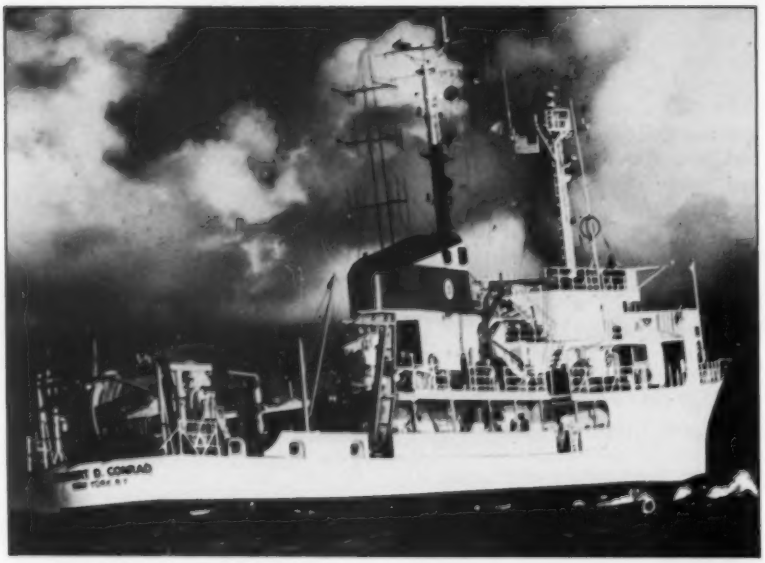


After their models have been verified, the two meteorologists will provide the results to NWS, which will integrate them into its operational forecasting.

An educational program is also under way, to help fishermen and other industry users interpret the coastal weather information that NWS will produce. LSU Sea Grant Marine Advisory agents will check it out with people who need the forecasts, helping them define and communicate back to the meteorologists their requirements and forecast needs.

Future NOAA marine forecasts and nowcasts will report on area weather as well as fast-developing and perishable weather situations throughout the Gulf of Mexico coastal zone. The information will be used by the National Weather Service, military weather services, and private forecast organizations for marine weather and oceanographic analysis and prediction.

The ultimate users, for whose benefit all of this is being done, will be coastal communities, marine transportation interests, recreational boaters, commercial fishermen, offshore construction enterprises, and the offshore energy industry. Safer commerce on the seacoast is the goal.



The catamaran Lulu *and submersible* Alvin *(at top) and the R/V* Conrad *comprised the fleet to explore the Galapagos Rift.*

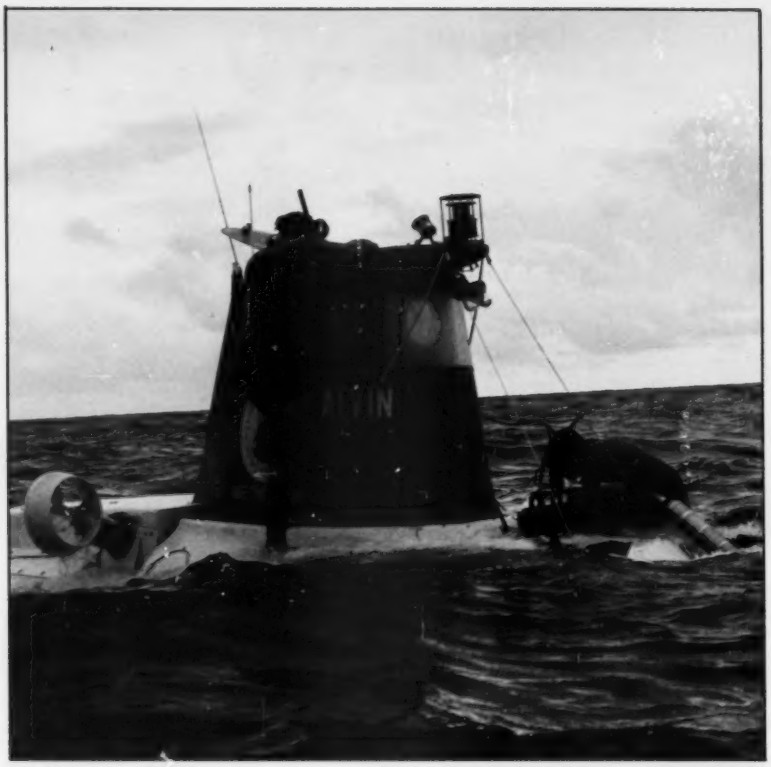
Large active faults and recent lava flows...A volcano split in two by the most recent earth movements along the active rift...Mineralized stacks, seamounts, resulting from the rapid precipitation of iron, zinc, and copper sulfides from hydrothermal vents above the faults...And "several hundred pounds of dense, metallic manganese ore of probable hydrothermal origin..."

These were among the discoveries reported by Dr. Alexander Malahoff chief scientist of NOAA's National Ocean Survey after deep-water explora-

Robert W. Embley is a research associate with the office of the chief scientist, National Ocean Survey.

Riddles of mineralization probed

Photos by expedition members, including Hank Chezar.



Divers ready Alvin *for docking with* Lulu *after dive (left). NOAA scientist Robert Embley (below and Dan Fornari of SUNY-Albany catalogue volcanic rock sample.*

Robert W. Embley

3,000 METERS UNDER THE SEA

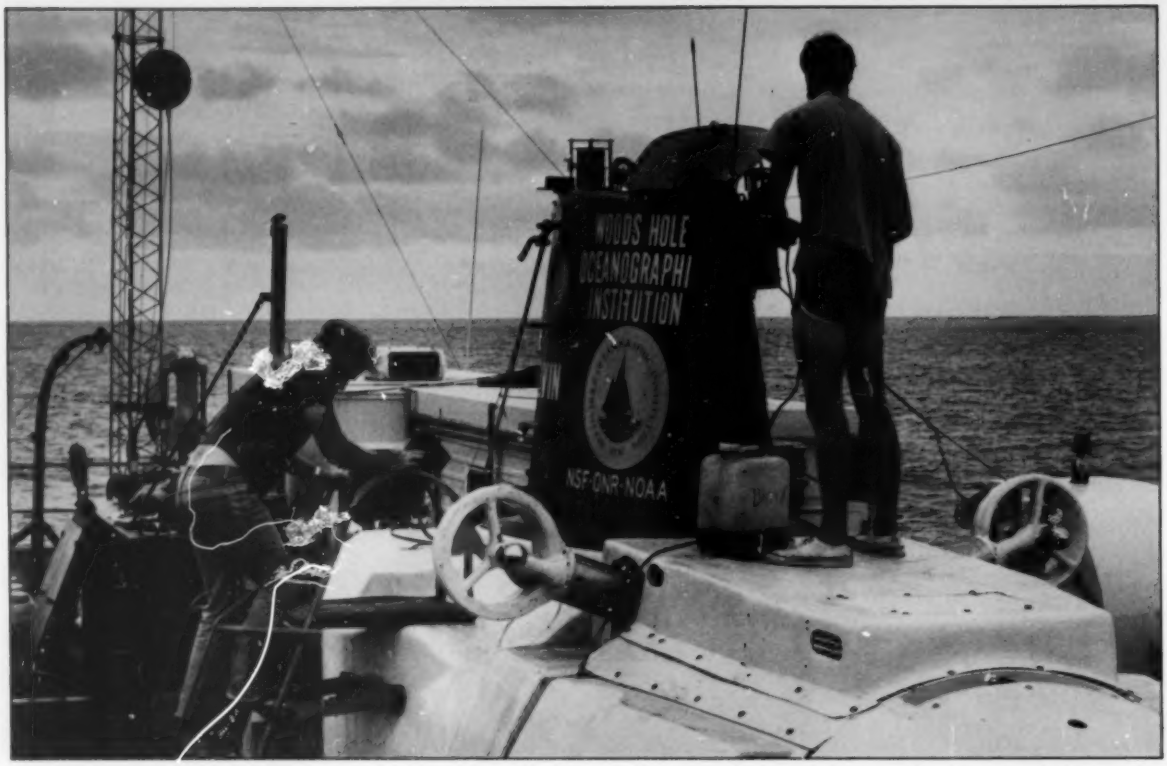
tion of the eastern end of the Galapagos Rift, 3,000 meters below the sea.

In the past 5 to 10 years, oceanographic expeditions have changed from relatively simple reconnaissance surveys, involving one or two scientists, into multi-institutional, multi-disciplinary operations involving five or more scientists. This transition has come about as a result of widened understanding of the complexity of ocean and ocean floor processes.

The R/V *Conrad* was engaged by NOAA to act as a support vessel to the submersible operations conducted from R/V *Lulu/Alvin*. The *Alvin* is a unique, deep-water submersible operated by Woods Hole (Mass.) Oceanographic Institution and jointly funded by the Office of Naval Research, NOAA, and the National Science Foundation. The submersible can dive to 4,000 meters and can retrieve up to 500 pounds of rock samples. It also has extensive video and photographic instrumentation. The catamaran *Lulu* is the *Alvin's* tender.

During the several days of transit time to the operation site, the scientists and technicians on board the *Conrad* prepared for deployment of the bottom transponder navigation system to guide the *Alvin* and the deep-towed camera system.

One of the touchy spots in this complex operation involved the transfer of personnel between the *Conrad* and the *Lulu* each night in choppy areas to survey the next day's dive site. After consultation with the *Conrad's* captain, Peter Olander, it was decided that the scientists would be transferred via the Nova Scotian dories aboard the *Conrad*. "Although the scientists involved



in the diving operations had an extensive background at sea," said Malahoff, "they did feel a certain trepidation in transfers to the R/V *Lulu*, a catamaran with a reputation as a rather rough-riding vessel."

At 5 a.m. on the first day of diving operations, the sea was predictably unsettled, with 6- to 8-foot swells rolling in from the western Pacific. Fortunately, the scientists had a competent "doryman" in Howard Giddy, a Nova Scotian who had been nurtured in the swells of the North Atlantic in a dory similar to the ones on board *Conrad*.

The transfer was relatively smooth, and the three scientists scrambled aboard *Lulu* at 8 a.m.

For several different reasons, it was a long-awaited moment. Malahoff had worked for three years to get the submersible into a place where he could study "the critical intersection of a major oceanic spreading center with a fracture zone similar to the California's San Andreas Fault," he said. Dr. Daniel Fornari, formerly of Lamont-Doherty Geological Observatory and now with SUNY-Albany, a specialist in volcanic rocks, was eager to examine and sample a recent volcanic center similar to Hawaii. I myself, a submarine geomorphologist involved in early reconnaissance studies of mid-ocean ridges, was looking forward to a first hand examination of an active volcanic spreading center.

Between 5 and 6 a.m. every day, scientists and crew members arose, had breakfast, and gathered on deck by the dory for transfer to *Lulu*. Most days three members of the scientific staff (two for diving and one to act as *Lulu-Conrad* communicator) and two members of the *Conrad's* crew transferred to Lulu.

At about 8:30 a.m., the *Alvin* was lowered into the water, and the two scientists and pilot eased themselves down into the 6-foot titanium steel spere, their observation and refuge from the tremendous water pressures for the next 8 to 9 hours. With the assistance of virtually everyone aboard the *Lulu*, the *Alvin* slowly backed out of its cradle and cast off its lines.

The average depth of water over the dive sites was 2,600 meters, or 8,614 feet (1.6 miles). The pressure of the water at this depth is more than 6 tons per square inch. Inside their sealed sphere, people feel no physical sense of this pressure only, perhaps, psychological. In fact, passengers in jet liners are more aware of pressure changes than are divers in submersibles.

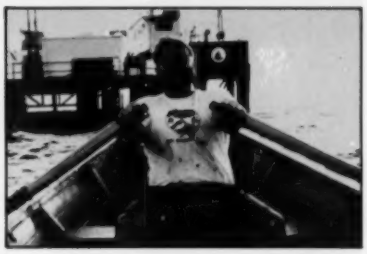
The descent to the bottom usually took 1.5 hours. Since bottom time is so precious, during the next 5 hours, scientists and pilot were completely absorbed in photography, observation, and sampling.

The views from the *Alvin's* observation port were of previously unobserved landscape. Man has, firsthand or photographically, observed more of the surface of the moon than of the seabed. While 75-58 percent of the seafloor is obscured by sediment cover, the NOAA scientists were operating in a "newborn" region of recent volcanic activity. Even so, much of the terrain was thinly covered with the remains of plankton falling from the rapid sedimentation zones in the overlying equatorial waters.

The undersea explorers soon gained new insights into the dynamics of the earth's plates. Recent fissures, rifts, and faults were observed during several of the dives. The scientists were especially surprised to discover a unique, central

Pre-dive checks in early morning hours (facing page) are followed by loading of instruments and cameras needed by scientists for the day's dive (left).

Lamont-Doherty Geological Observatory team (below) assembles transponder weights and floats prior to launching: Howard Giddy, Conrad *third mate, rows personnel to* Lulu *for day's activities.*



crack separating, in some cases by only 1-2 inches, two major crustal plates.

Another major discovery was a mineralized ridge composed of sulfides of iron, copper, and zinc. The intersection area between the active "transform" fault and the spreading rift valley occurred over a very short distance, less than 0.5 km. The spectacular active faults on the fractured ridge were perpendicular to the rifts and fissure in the Galapagos rift.

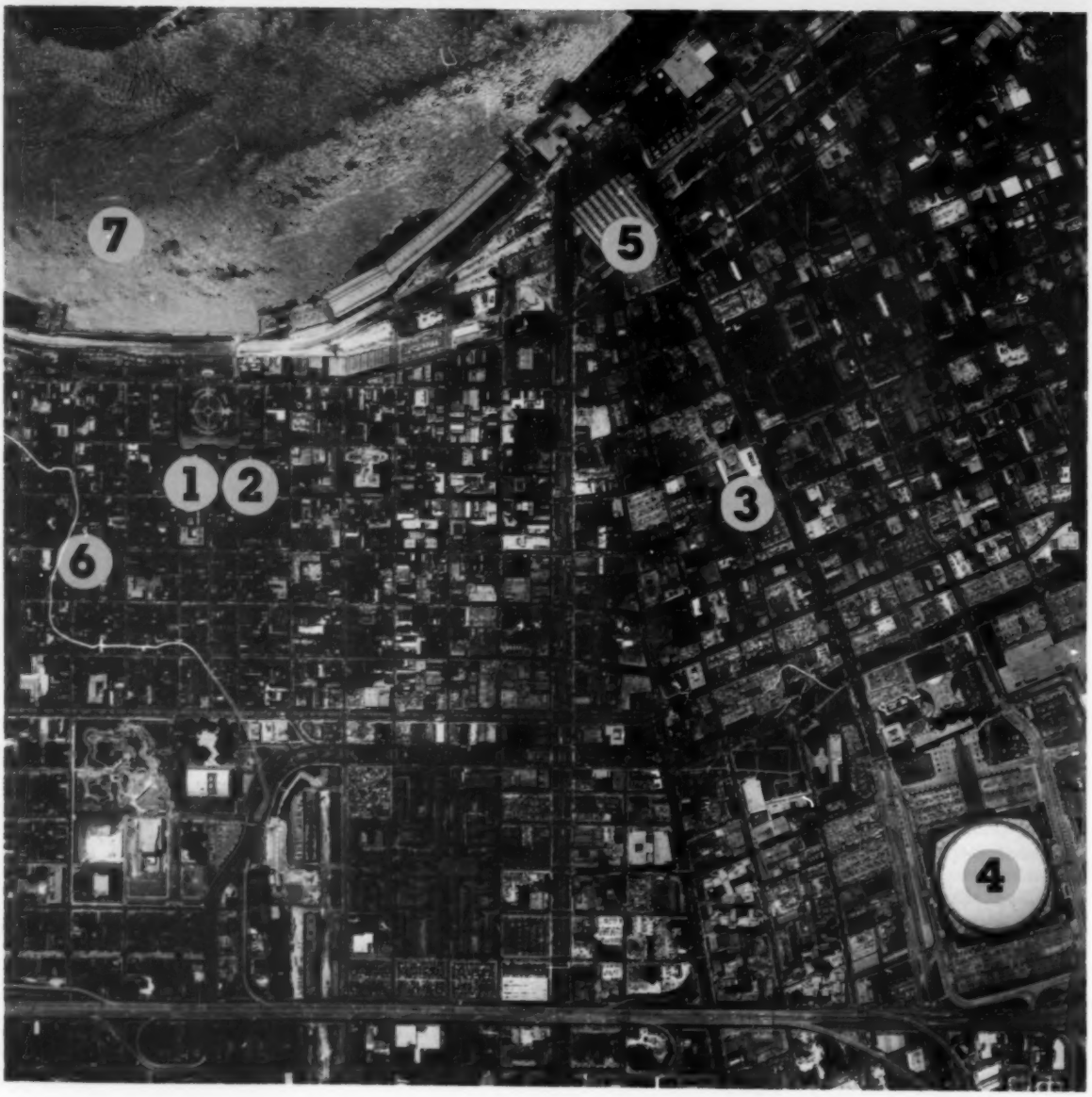
Afternoons at 3:30 the *Alvin* would begin its ascent to the surface. This could be an unpleasant time, surfacing, particularly in rough seas, without a horizon to fix, in a roll-prone craft like the *Alvin*. By 5:30 p.m., the *Alvin* docked, and the scientists would catalog the day's samples.

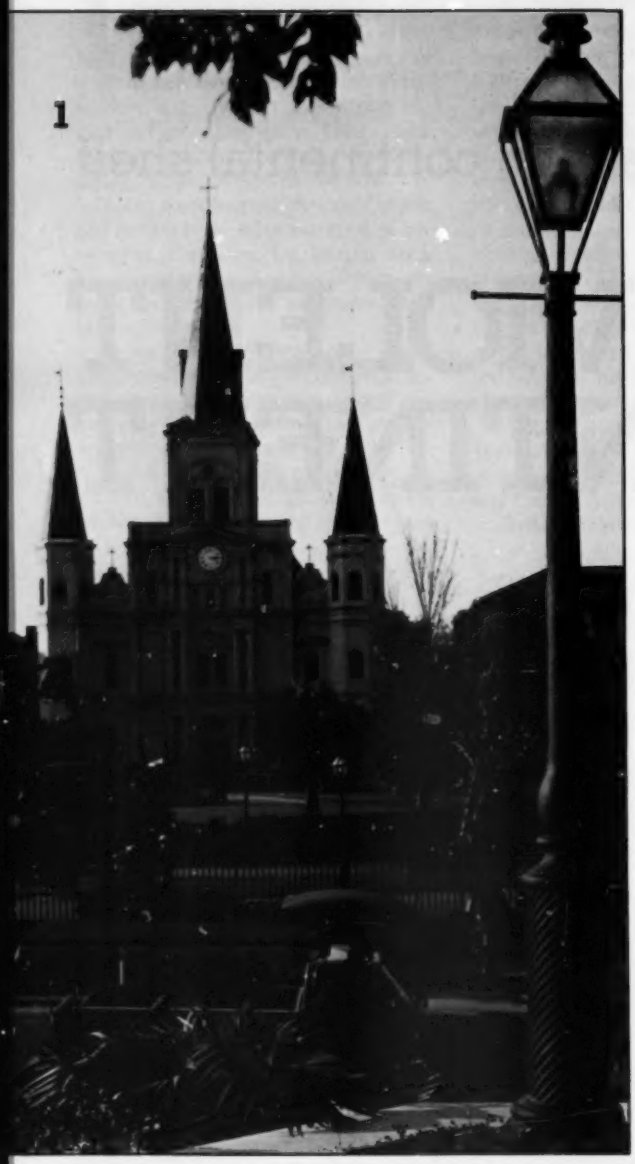
To celebrate the *Alvin's* one-thousandth dive, which occurred during the expedition, there were two "1,000th Anniversary" cakes at a party on the R/V *Lulu*. Two days and two dives later, the party headed back to the United States.

The study area and the dive sites extended along a 50-mile stretch of the Galapagos Rift and fracture zone, a volcanically active, mile-wide fault where the oceanic crust is being generated. Extensive mineralized stacks and mounds were found at the edge of the fault. In one part of the active rift, Malahoff said, the expedition had found and mapped "a mile-long ridge containing mineral deposits."

Next year, a follow-up expedition will return to the area to explore the northern extent of the fracture ridge and determine the extent of the sulfide and manganese deposits.

CITY SCAPE





The aerial photograph of the downtown area of New Orleans was taken at 17,500 feet by the National Ocean Survey's Air Photo Mission II on June 12, 1979. Chief of Mission, Cdr. Bernard N. Mandelkern; Co-pilot, and Navigator, Lt. Cdr. Richard K. Muller; Photographer, Charles W. Papke.

Jackson Square, in the heart of New Orleans' French Quarter, has been described as "the finest architectural setting in the U.S." Its crown jewel is the city's oldest church, St. Louis Cathedral (1), erected in the period of 1788-1794. Destroyed by fire and rebuilt in the 1850's, the cathedral is one of the oldest and most photographed churches in the country.

Flanking the cathedral is the Presbytere (2),built circa 1791-1813 as a rectory. It now houses a section of the Louisiana State Museum.

A solid, old citadel of the city government for 108 years is Gallier Hall (3). Designed in 1850 by the New Orleans architect James Gallier, Sr., the building is an excellent example of Greek Revival architecture. It is located midway between the city's newest structures—the Superdome (4) and the Trade Mart (5).

Although the undisputed center of the city's nightlife is Bourbon Street (6) where the blare of the discotheque competes with traditional Dixieland jazz, it is along the narrow thoroughfares near the Mississippi River (7) where the day traditionally begins and ends in the little cafes with homemade doughnuts and cafe au lait with or without chicory.

The eastern continental shelf

VIOLENT CONTINENT

Louise Purrett-Carroll

If Atlantis sank on the continental shelf, we might have a hard time finding any trace of it.

The conventional notion, of scientist and layman alike, is that if the sea level rises, it quietly seeps over the land and everything on it. Hills, buildings, river valleys would lie, slowly decaying, beneath the waves for eons.

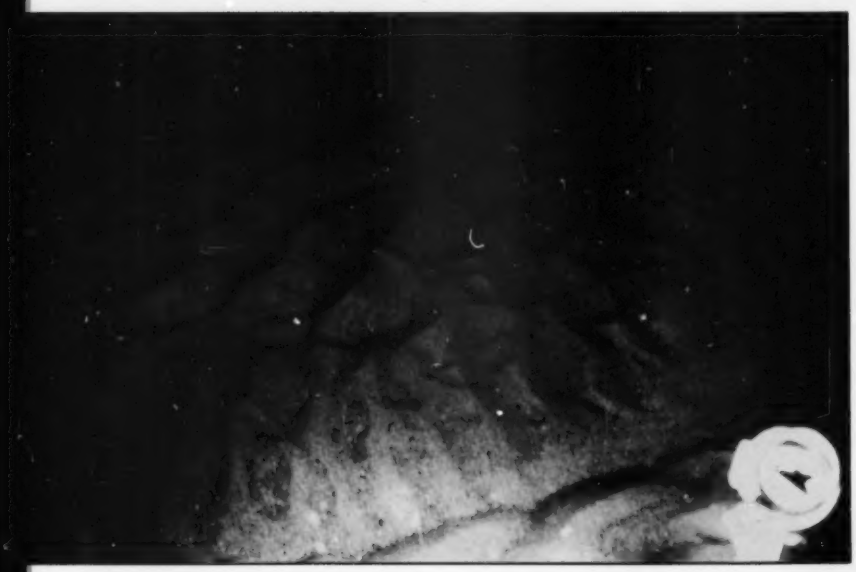
Not so, according to a National Oceanic and Atmospheric Administration oceanographer. For years, Dr. Donald Swift has been studying a region flooded by rising seas, the eastern continental shelf of North America.

He has found it to be a violent world, with its own "weather" of currents, tides, and waves that shape and reshape the landscape of the sea floor. Valleys are scoured out and filled; sediments are picked up, moved thousands of feet, and dropped again by a single storm at the surface; islands form and migrate landward; avalanches sculpt undersea canyon walls.

Swift, a researcher with NOAA's Atlantic Oceanographic and Meteorological Laboratories in Miami, Fla., explores this world with conventional and unconventional methods, lowering cameras to collect photographs of the bottom, retrieving cores of sediment, sounding the bottom with sonar, even descending, like an astronaut landing a spaceship on an alien planet, in a two-man submersible lowered from a mother ship. His trips to the bottom, he says, are useful "because it gives one a direct personal experience of the sea floor. I could see small-scale features that might only be caught by chance by a camera."

Most of Swift's work has focused on the Mid-Atlantic Bight, the section of continental shelf between Cape Hatteras and Cape Cod. But he has also worked with Argentine scientists on the shelf off their nation and plans work next winter on Spain's continental shelf.

NOAA scientist Donald Swift dives into waters off Virginia Beach to check current meter (opposite page and left). Ripples in sediment on the continental shelf off Cape Hatteras (below) were the seafloor's response to a strong current, perhaps the Gulf Stream, says Swift.



Over the eons, the continental shelves—the underwater extensions of present-day continents—have played a dual role directed by the expanding and contracting polar ice sheets. Sometimes they are dry land, other times ocean floor. During an ice age, the great glaciers monopolize much of the world's supply of water, draining the seas and baring land. It is thought that at the peak of the last glaciation some 19,000 years ago, worldwide sea level was about 410 feet (125 meters) lower than now. In most parts of the world, says Swift, the oceans retreated to the edges of the continental shelves. "You could walk 90 miles (140 kilometers) out from where New York City is now. Off New England, where the shelf is really wide, you could go out several hundred miles. Nova Scotia would have been twice as large as it is now."

For the duration of the Ice Age, this newly exposed land took on all the characteristics of land elsewhere. Rivers cut valleys through it, animals roamed it, Indians took up residence and hunted mammoths there. "We know there were large animals living in what is now the Mid-Atlantic Bight," says Swift. "Once in a while a fisherman will find a tooth from a mastodon or mammoth in a net. The area was so large that a separate sub-species of mammoth evolved there."

As the climate warmed again and the ice caps melted, the waters returned to the sea and it gradually rose, flooding the continental shelves once again. "There's a big argument among scientists over whether the sea level is still rising," says the NOAA researcher. "Probably it still is; we still have ice caps, and they are still melting. The process is cyclic anyway. The climate warms, the ice caps melt, then it gets colder and they build up again."

Swift's research has a duality like his subject. His underlying theme is sediment dynamics on the shelf—how sediments accumulate and are moved around. But it takes forms that can be profoundly basic or highly pragmatic, affecting not only the origin of topographic features but also pollution disposal, offshore drilling, shoreline construction—even archaeology. Swift's work is undermining many traditional assumptions, rewriting continental shelf history.

He has, for example, revised theories on the origin of certain underwater valleys. The Delaware Valley is one of a series of valleys that transect the conti-

nental shelf east of the United States. These valleys generally thought to be the remnants of river valleys, cut when the shelf was exposed and rivers flowed across to the sea. In fact, they were considered classic examples of relict topography.

The trouble with this interpretation, says Swift, is that the shelf valleys are not shaped like river valleys on land. Instead of having gently sloping sides that climb toward a sharply defined ridge, the shelf valleys are steeply cut and separated by broad, flat plateaus, a geologically younger type of topography. Swift, from his studies of the Delaware Valley, believes it never was a river valley, but was scoured out, and is still being scoured, by tidal currents. It was formed not on land, but under water. As the sea level rose, he continues, the area of scour moved landward, scooping a valley perpendicular to shore. "Since I did that study," he adds, "another scientist has found the original Delaware River valley buried under many meters of sediment and offset about a kilometer from the present seafloor valley."

Barrier islands, long narrow islands that closely parallel the shore—such as Padre Island off Texas—are also formed by currents, with some help from wind and waves, says Swift. They result from processes in the surf zone—the region about 300 feet (100 meters) from the beach—where the continental shelf is wide and gently sloping. In this area, strong surface waves and currents parallel to shore work to straighten out the shoreline, Swift explains. They erode headlands and carry the sand to fill bays. As sea level rises, the beach, and the dunes behind it, also rises, built up by sand washed or blown ashore. But the area behind the dunes doesn't rise, and eventually floods to form a lagoon.

The landward side of the lagoon becomes a second shoreline, one that is irregular because there are no coastal currents to smooth it out. As the sea continues to rise, Swift says, the whole system moves landward. The seaward side of the barrier island is eroded, and sand washes over the tops of the dunes during storms, building up the landward side of the island.

"If you follow a single grain of sand that starts on the outer beach, it would be blown from there to the lagoon side, and as the seaward front of the island erodes away, that same grain would eventually find itself on the beach again. It moves like a tank tread."

Swift's understanding of processes and landscapes on the continental shelf recently came to the aid of archaeology. "If the shelf was once dry, then presumably there were people living there," he explains. "A hot topic in North American archaeology is the paleo-Indian problem. There is evidence that the shelf area now under water was inhabited 10,000 to 12,000 years ago by early Indians who used very specialized tools that may have been designed for big game, like elephants."

The Bureau of Land Management, which leases sites for offshore oil drilling, must make sure that any attempts to exploit resources will not disturb potential archaeological sites. So, it funded a study to identify areas where traces of these Indians might be preserved. Swift was a consultant on that study.

"The basic conclusion is that the old land surface was either destroyed by the rising sea or buried by sediments. If it's buried, it's preserved." The final report, being prepared by the Institute of Conservation Archaeology of Harvard Uni-

National Park Service

Along the edges of the "violent continent"—dredging, dunes, and (opposite page, top left) the Ambrose Light, now a platform mounted on the continental shelf. Dr. William Lavelle begins test of system for tracking sediment movements (far right); later, he checks data from the instrument, now resting on the ocean floor.

versity's Peabody Museum, divides the continental shelf into areas of greater or lesser probability for finding buried archaeological sites.

Swift deals with the future as well as the past. The continental shelves are to be the scene of unprecedented activity in the decades to come. Leases are being issued for oil drilling there. Construction is contemplated not only for drilling platforms but also for sea-floor pipelines and such massive structures as power plants. Dredge spoils, sewage, and other refuse end up there.

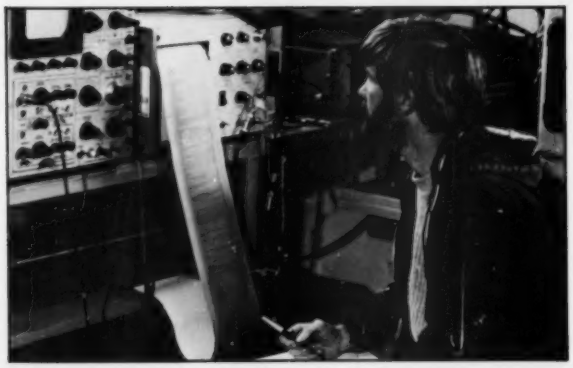
Here sediment dynamics have immediate application. Swift can identify areas where the bottom is too strongly scoured by currents to allow safe drilling or construction. The pattern of underwater weather is especially important for predicting dispersal of pollutants and planning disposal operations so that wastes remain where they are dumped and do not end up on the beaches or in important fisheries.

For several years, as part of a major NOAA study of the relationship between the New York Bight and the dense human population adjoining it, Swift headed a sediment transport study there. With instruments they designed, he and his colleagues recorded currents and sediment movements for periods of 2 weeks to 2 months over several years. Radioisotopic tracers were used to track movement of dredged materials at dumpsites. The study showed, for example, that sediment moves only during major storms, usually "northeasters," but that one large storm can shift it almost a mile.

This summer, Swift has done more work in the Bight for the New York District, U.S. Army Corps of Engineers. Channels into New York harbor have to be dredged periodically because silt and other materials accumulate to make them too shallow for large ocean liners. The channels are due for another dredging, but the Corps is concerned about how and where to dump the dredged sediments. A plant on the Hudson has been leaking synthetic organics (PCB's) into the river, Swift explains. The pollutants move downriver with the sediments and contaminate the bottoms of the channels. "If they dredge to deepen the channel, what do they do with those contaminated sediments? They can't dump them in the usual way."

The idea, he says, is to dump the contaminated sediments, then cap them with uncontaminated material. The question is, will the cap hold, or will it be swept away to release the contaminants. The Corps is considering a plan in which Swift and his colleagues would monitor the cap for a year. These measurements, combined with what they already know about the Bight, should allow them to predict whether and how long the cap will seal in the contaminated sediments.

These types of studies must become more common in years to come. In the past, human activity on the continental shelves was limited to the ice ages, when the descending seas drained them dry. Now, humanity doesn't need the encouragement of an ice age to begin moving out on the continental shelves. Their rich resources, and the geographic proximity that makes them convenient places to build or dump, assure that they will, in a sense, be "inhabited." As we move more into this violent world that is neither land nor deep sea, there will be increasing need for the esoteric-sounding science of "sediment dynamics."



Dr. George Maul has welcomed miniaturization and other changes in oceanographic instrumentation, but much over-the-side work with large equipment is still necessary, as shown by Johns Hopkins scientists using a plankton net in Chesapeake Bay, for samples brought into the laboratory space of the Ridgely Warfield *(right).*

Permission to reprint Dick Tracy courtesy of C.T.N.Y.N.S.

CHANGING TOOLS OF A CHANGING TRADE

Carl Posey

To the land-bound observer, oceanography has always seemed a science populated by hirsute men in khaki shorts, straining over the large, leaden shapes of their massive equipment. You could tell oceanographers by their brawny backs and blueveined legs, mutations of their trade.

Artifacts of this oceanographic Iron Age abound, immovably heavy objects, rusting through bright coats of orange paint—buoys as beefy as Civil War ironclads, stacks of iron locomotive wheels as weights. There was something haywire and heavyhanded even in the way things worked. To sample water and measure temperatures where the water was sampled, for example, you deployed a string of Nansen bottles, then loosed a messenger weight down the cable to

There's still a lot of mulehauling.

trip them. Tripped, the bottles flipped over, engorging a sample of water and measuring water temperature simultaneously.

But today, thinks this land-bound observer, something must be different—oceanography must finally have become a science at which even the weak-backed can excel. Or does this discipline merely prove once again the French axiom: the more it changes, the more it's the same thing?

"It has changed," says Dr. Robert Burns, who was a research oceanographer with the small wet corps of scientists in the former Coast and Geodetic Survey, now with NOAA's Office of Marine Pollution Assessment, stationed in Seattle. "It's definitely changed from what we used to call beards and B.O. oceanography. There's still a lot of mulehauling, but you get more help, especially on the larger ships. Twenty years ago we did everything ourselves, and the most important piece of equipment we had was a clipboard and a sharp pencil. The computers do so much now, you see."

But in marine geophysics, Burns' specialty, sampling techniques are close to what they have always been. "We still tend to get the classical types of sample, a dredge or grab or core," he says. "But there's increasing emphasis on suspended sediments, and we begin to see things like nephelometers and sediment traps."

The turn toward suspended sediments—the small particles that float in the water column and constitute both sink and source for certain pollutants—derives from a raised consciousness about the health of the marine environment. A better sediment trap is something like a better mousetrap, for the oceanographic world has definitely made a path to the door of Dr. Richard Feely, with the Pacific Marine Environmental Laboratory also in Seattle. So respectable has sediment-trapping become that it was recently the subject of an 11-organization intercomparison experiment—a mark of respectability usually accorded only the more venerable sensors.

Dr. George Maul, a physical oceanographer with NOAA's Atlantic Oceanographic and Meteorological Laboratories in Miami, sees major changes in his field. "Miniaturization has been wonderful," he remarks, "especially for those back muscles." He cites a crucial difference between the way data are obtained now and in the old days. "The old string of Nansen bottles has about disappeared. Now we use continuous vertical profiling devices, like the CTD (from conductivity-temperature-depth), which gives continuous measurements down through the water column. And we combine rosettes of water samplers—controlled by electronics, not messenger weights—in combination with CTD's."

Of course, one reflects, watching oceanographers wrestling a large rosette full of seawater on a rolling deck is still like watching sailors trying to tie down a runaway cannon on a man o' war.

Dr. Donald Swift, a marine geologist at the Miami laboratories, shrugs off the physical effort. "Weight hasn't changed much, but the stuff is very sophisticated now. But you're still out there with big winches lowering these things over the side." He pauses, then adds, almost with a shrug, "I started out as a terrestrial geologist, with boots and a pick. Moving into oceanography you get a little spoiled having that big deck and all those strong sailors around to help out."

Specializing in the sediment dynamics of the Atlantic continental shelf, Swift probes the world that was submerged after the last great Ice Age. Now he is helping rewrite much of the conventional wisdom of how that vanished iand has fared over the intervening epochs. His work has been a blend of diving in submersibles to visit this natural laboratory a number of fathoms deep and deploying complex remote-sensing systems to monitor longer-term processes on the shelf.

"I think we have the same problem in oceanography that NASA (National Aeronautics and Space Administration) has in space exploration: whether to use manned or unmanned vehicles. It seems to me that manned systems are good in the early stages of exploration. Then, as our abilities evolve, we have to go to very sophisticated unmanned systems."

You mean two-man submarines are *not* the ultimate oceanographic tool?

"Submersibles give us a kind of geotourism, I think. I need to get storm effects along the bottom, so I need to have something that can be put out for a long time, waiting for storms to come along. So we developed our boundary-layer sensing systems.

"Of course, some discoveries are impossible without a deep-diving, manned system. The discovery of metallic sulfite geysers in the equatorial Pacific....that couldn't have been done without a submersible. Still, eventually they'll need to put down more complex sensors that can stay down and function without human help. On the continental shelf, a dive was crucial for us the first time out. But after that we went to current meters and nephelometers."

The space analogy goes further. Swift notes that a group led by Dr. Charles Hollister, of the Woods Hole Oceanographic Institution, plans to do in the deep ocean what Swift's group is doing along the shelf. "Hollister calls his boundary-layer systems 'landers,' and they're being built by the Jet Propulsion Laboratory."

Certainly the problems of space exploration and probing the global ocean have this in common: both send equipment that must perform reliably for a long time into an environment that is not well understood but that has a voracious appetite for the things people make out of metal and synthetics.

Only a very few organizations in the world, for example, have been able to implant moored sensor systems in the deep ocean—in water more than two miles deep—and recover the systems and their data months later. One of them is the Pacific Marine Environmental Laboratory group led by Dr. David

Halpern. And he, faced with the space-age problem of having probes go out into that hostile environment, doesn't see much improvement on the mechanical side of things.

"My equipment, the large moored instrumentation systems, even the new current meters, are the same size. It still takes two guys to pick up everything, and everything has to be able to survive being dropped on the deck. The mechanical aspects haven't changed much, and it is very hard work. It takes about 8 hours, and about 8 people and a large research vessel to put out a moored buoy and its string of underwater sensors." Then he adds, "But inside the heavy shells, there is space-age electronics. We can record a lot more than we used to be able to." Then, "But at the other extreme, our buoys still use those frail, primitive cups to measure wind speed."

Biologists still use frail nets to try to sample the microlife of the sea, with mixed results. "I think biological sampling is still pretty backward," comments Marcia Glendenning, a biological oceanographer with the Seattle lab. "Everybody all along has felt we're only capturing the blind, weak, lame and dying, those who can't escape. Hence the shift to using acoustics and electrically controlled multiple net systems to detect scattering layers. The problem for biologists is trying to second-guess little beasts whose behavior we don't understand very well."

One finds other differences as well.There are robot boats to take samples some distance from the contaminated ship, sounders that float along density layers underwater, CTD's that take an extremely fine-grained look at how those characteristics change with depth, devices designed to cycle up and down automatically, a host of wave-riding, air-sea-sensing buoys, and instruments that can be left submerged for months, then whistled back to the surface with an acoustic signal.

What about the field of oceanography itself? "For one thing, there's an increasing reliance on tools," says Burns. "If the computer breaks down, there aren't many oceanographers left who can hand-reduce the data. You find fewer and fewer people involved in all aspects of a project. Used to be, we'd design an experiment, carry it out, reduce the data....in some ways, this gives you more continuity. Now it's more compartmentalized. And we used to spend a lot of time on the way out and back analyzing data. Now it seems all our new instruments and computers are generating a monstrous amount of data we never seem to have time to analyze."

Burns also notes that the field is much larger. "Twenty, twenty-five years ago, all the oceanographers in the United States could get together in one room at the American Geophysical Union meeting. And there were lots of familiar faces. Now we meet in five or six rooms, and you see more people you don't know. What's happened is there's been a lot of specialization. Now instead of just an oceanographer you have biological oceanographers, physical oceanographers, and so on, and there isn't a lot of lateral communication from specialty to specialty. The general practitioner in oceanography is regarded by specialists in our field in about the same way you find medical GP's (general practioners) regarded by medical specialists."

One of the big differences in oceanography, of course, is that more and more women have chosen seagoing scientific careers.

"At Johns Hopkins," remembers Marcia Glendening, "we used to go out on a 110-foot catamaran in Chesapeake Bay and over the continental shelf. We spent about one week out of every month on the boat, with everybody doing everything. Well, then it was new to have women out there doing this kind of work, operating winches and things. Since I was the only woman aboard, there was some opposition initially. It used to bother people. But since then there's been a big attitudinal shift for sure. Women are able to do more. We even have female deckhands on NOAA ships now. Still, it would have been rough 10 years or so ago to be a woman chief scientist on a large ship..."

Dr. Mary Jane Perry, a biological oceanographer who is a research assistant professor at the University of Washington, doesn't know why. "I never experienced any lack of cooperation as a chief scientist, and I really don't see that much difference between then and now. When I first started to go out about 10 years ago, it had been only a few years since a female couldn't be the only woman on the ship. Sailors are often risking their lives, so they have their superstitions, like not whistling in the galley or allowing women to sail. I think these are fading. I've heard that women have been discriminated against in oceanography, but it's never happened to me.

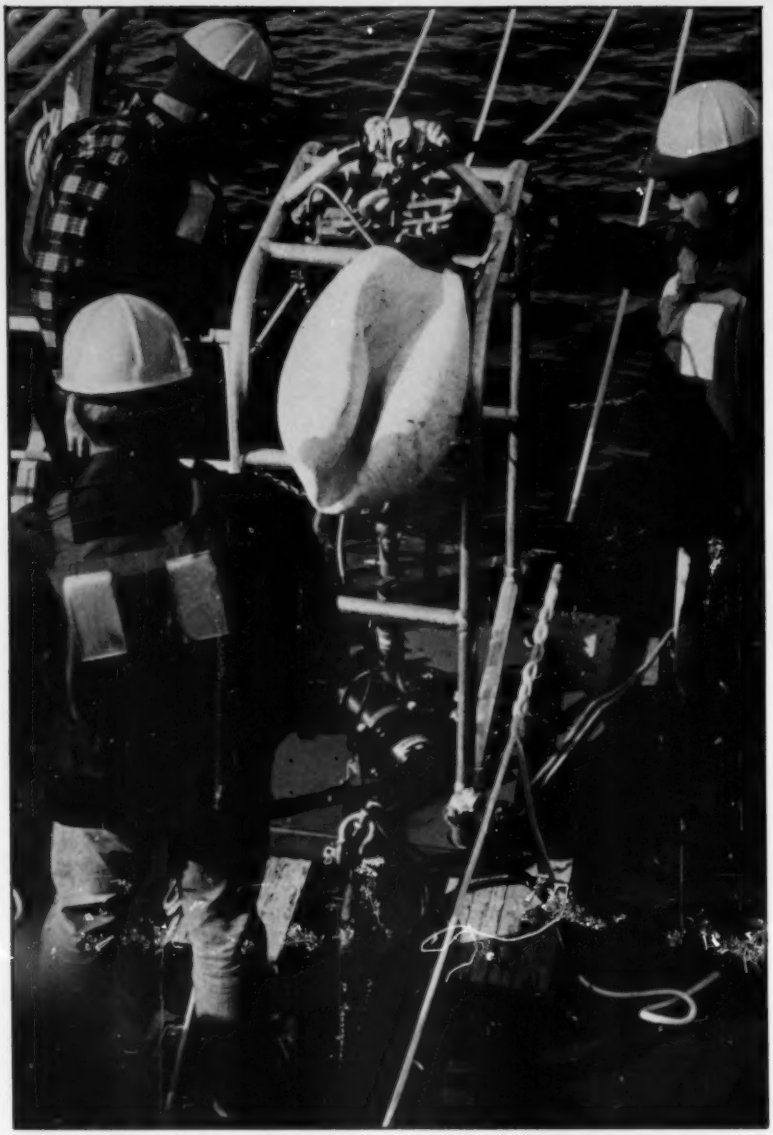
"Of course, there haven't been many women in the field. I recently attended a meeting where there were about 30 oceanographers, and I was the only woman. There just aren't that many senior women oceanographers yet. But females are coming up fast. There seem to be as many females as males in graduate school in biological oceanography." She adds some euphotic metaphor: "It's just a matter of time before they mix up into the higher ranks of oceanography."

Was it, one wonders, the heavy hauling that kept women out of the field all those years? Her answer is emphatically negative. "Physically, there's no problem at all. For very heavy gear there are winches and cranes available. There are strong men and there are strong women who pitch in, just as there are both men and women who prefer to keep clean."

Glendening echoes this. "No real delicate female goes into oceanography. If I didn't enjoy getting out and working hard in the sun and weather, I wouldn't do it."

It may be that no really delicate person goes into it. The level of discomfort in going to sea has always ranked pretty high; where it involves the extraction of new knowledge from an often rather close-mouthed, angry ocean, it can be a downright poor way to earn a living. As Dr. John Apel, who directs the Seattle laboratory, says, "There's a certain amount of self-flagellation involved in oceanography."

Then, is there a possibility that in the best of all possible worlds, one could do one's oceanography without going to sea? What about remote sensing? Halpern muses, "Maybe something like Codar, or Seasat, will bring us the ultimate oceanographic weapon,



Complex instrument package developed at Atlantic Oceanographic and Meteorological Laboratories is designed to sit on ocean floor and monitor the factors that control sediment movement.

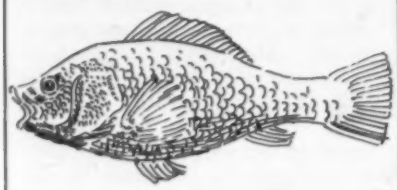
where you can stay home." He refers to the coastal dynamics application radar, developed by NOAA scientists in Boulder, and capable of scanning the coastal sea surface and measuring surface currents over hundreds of square miles in virtual real time; and to the ocean-watching satellite that will ultimately observe the sea as closely as NOAA and Nimbus spacecraft observe the atmosphere.

Apel, whose career has centered on using satellite remote-sensing to oceanographic ends, shakes his head over this one. "One thinks of remote sensing as a way of staying in your office and not getting seasick. But of course you have to go to sea. Remote sensing is just a new tool that we're getting steadily better at using. But it only gives you surface oceanography, and mainly the physical part. It doesn't offer much chemistry or biology.

On the other hand, you can't solve something like the climate problem without have the continuity and reach that remote-sensing provides. This is going to increase, too. Right now, there's not enough ship time available for our program, much less for the whole oceanographic community's. The rising cost of fuel complicates matters further. So remote sensing will get more and more important."

And George Maul, also a specialist in satellite oceanography, uses a line from Leonardo da Vinci to stress this need to go to sea: " 'Remember, when discoursing about water, to induce first experience, then reason.' "

Draw up to the hearth and enjoy these tempting dishes that are sure to warm you on the coldest days ahead. In the first difficult months, the Pilgrims learned to appreciate clams and used them to fill empty bellies when all else was gone. The Cape Cod Turkey has little in common with the big-breasted bird that graces most Thanksgiving tables, for this turkey is really a fish. The traditional Boston Baked Beans are even better cooked with fresh fish.



Pilgrims' Pride

CAPE COD TURKEY WITH EGG SAUCE

2 pounds cod fillets or other fish fillets, fresh or frozen
1 teaspoon salt
1/4 teaspoon pepper
2 tablespoons melted margarine or butter
4 cups fresh bread crumbs
2 tablespoons melted margarine or butter
2 tablespoons grated onion
2 teaspons dill weed
2 teaspoons chopped parsley
1 teaspoon leaf thyme
1/2 teaspoon salt
Dash pepper
2 eggs, beaten
Egg Sauce
Sliced egg

Thaw fish if frozen. Sprinkle with salt and pepper. Place half the fillets in a well-greased baking dish 12 x 8 x 2 inches. Combine bread crumbs, 2 tablespoons margarine, onion, dill weed, parsley, thyme, salt, pepper, and eggs. Mix well. Spread on top of fillets in baking dish. Use remaining fillets and place on top of stuffing. Brush with 2 tablespoons melted margarine. Bake in a moderate oven, 350° F., for 35 to 40 minutes or until fish flakes easily when tested with a fork. Serve fish with Egg Sauce. Garnish with sliced egg. Makes 6 servings.

EGG SAUCE

1/4 cup margarine or butter
1/3 cup all-purpose flour
1 teaspoon dry mustard
1 teaspoon salt
1/8 teaspoon white pepper
4 cups half and half
1/2 teaspoon liquid hot pepper sauce
5 hard-cooked eggs, chopped
2 tablespoons chopped parsley

In a saucepan melt margarine. Stir in flour, mustard, salt, and pepper. Add half and half gradually, and cook over low heat until thick and smooth, stirring constantly. Stir in liquid hot pepper sauce, chopped eggs, and parsley.

PILGRIMS CLAM PIE

3 dozen shell clams
or
3 cans (8 ounces each) minced clams
1 1/2 cups water
1/4 cup margarine or butter
1/2 cup sliced fresh mushrooms
2 tablespoons minced onion
1/4 cup all-purpose flour
1/8 teaspoon liquid hot pepper sauce
1/4 teaspoon dry mustard
1/4 teaspoon salt
1/8 teaspoon white pepper
1 cup reserved clam liquor
1 cup half and half
1 tablespoon lemon juice
2 tablespoons chopped parsley
2 tablespoons chopped pimiento
Pastry for a 1-crust 9 inch pie
1 egg, beaten

Wash clam shells thoroughly. Place clams in a large pot with water. Bring to a boil and simmer for 8 to 10 minutes or until clams open. Remove clams from shell and cut into fourths. Reserve 1 cup clam liquor. (OR: If using canned clams, drain and reserve 1 cup liquor). In a skillet melt margarine. Add mushrooms and onion and cook until tender. Stir in flour, mustard, liquid hot pepper sauce, salt, and pepper. Gradually add clam liquor and half and half. Cook, stirring constantly, until thick. Stir in lemon juice, parsley, pimiento, and clams. Pour mixture into a 9-inch round deep-dish pie plate (about 2 inches deep). Roll out pastry dough and place on top of mixture in pie plate; secure dough to the rim of the pie plate by crimping. Vent pastry. Brush with beaten egg. Bake in a hot oven, 375° F., for 25 to 30 minutes or until pastry is browned. Makes 6 servings.

BOSTON BEAN SKILLET

1 1/2 pounds ocean perch fillets or other fish fillets, fresh or frozen
1 teaspoon salt
1/4 teaspoon pepper
4 slices bacon, diced
1 cup chopped onion
1 clove garlic, crushed
1/2 cup light brown sugar
2 tablespoons prepared mustard
1 can (1 pound) lima beans, undrained
1 can (1 pound) butter beans with molasses and bacon, undrained

Thaw fish if frozen. Cut into serving size portions. Sprinkle with salt and pepper. In a large skillet cook bacon until almost done: Add onion and garlic and cook until onion is tender. Stir in brown sugar, mustard, lima beans, and butter beans. Bring mixture to a boil and simmer for 20 to 25 minutes, stirring occasionally. Place fillets on top of beans in skillet in a single layer. Cover and simmer for 4 to 5 minutes or until fish flakes easily when tested with a fork. Makes 6 servings.

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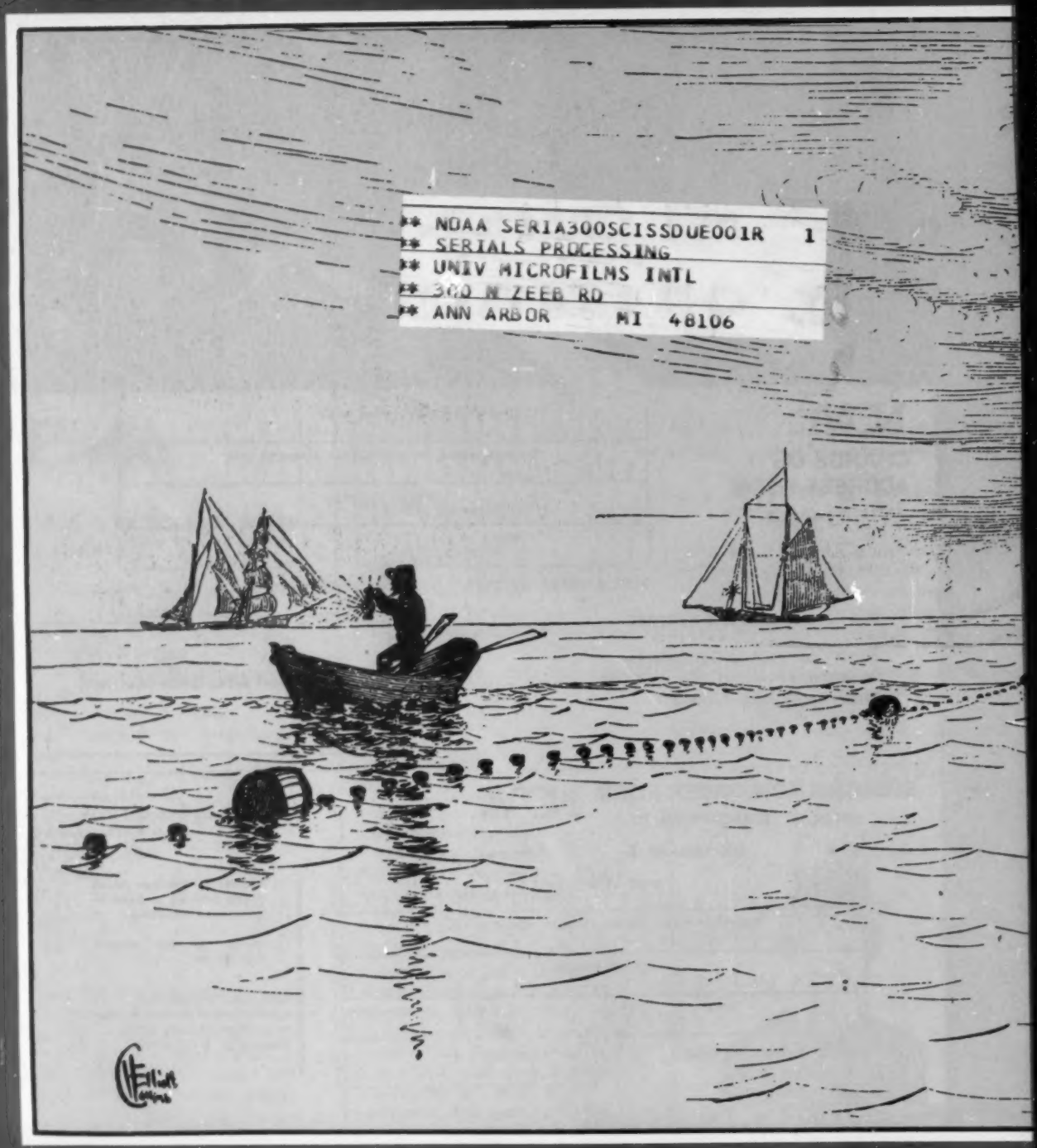

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